

BENTON HARBOR POWER PLANT LIMNOLOGICAL STUDIES

PART XXX

ENTRAINMENT OF PHYTOPLANKTON AT THE
DONALD C. COOK NUCLEAR PLANT - 1979

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INTRODUCTION

The Donald C. Cook Nuclear Plant is a 2,200 megawatt steam electric generating station situated on the southeastern shore of Lake Michigan about 18 km south of St. Joseph, Michigan. At full operation, the plant uses roughly 6,300 m³/min of lake water in once-through cooling of its condensers. Waste heat is returned to the lake in cooling water heated to no more than a maximum of 12-13 C° above intake temperature for unit #1 and 9-10 C° above lake temperature for unit #2 as required in the Environmental Technical Specifications for the plant. Prior to January 1979, the plant used chlorination twice daily for chemical defouling of heat exchangers and turbine condensers.

The Environmental Technical Specifications of the plant require an assessment of entrained phytoplankton abundance, viability, and species composition to be made on a monthly basis on samples collected in the early morning, at mid-day, and in the late evening.

SUMMARY OF OTHER STUDIES

Other power plant studies are summarized in Rossmann et al. (1977). These studies have shown that phytoplankton may suffer inhibition or death due to entrainment and condenser passage. In addition, changes in community structure have been noted. Various authors have concluded that temperature rises which can be tolerated by phytoplankton range from 8 C° to 11 C°. The actual temperature change that can be tolerated by phytoplankton is related to the intake water temperature; the lower the intake water temperature the greater the tolerable temperature rise (See Rossmann et al. 1977). If chlorination is also taking place, phytoplankton may be killed outright or suffer varying degrees of

inhibition in productivity. At elevated temperatures, communities have been observed to exhibit a decreased diversity promoted by a shift from a diatom dominated community to one dominated by either green algae or blue-green algae. Finally, some evidence exists which suggests that phytoplankton productivity may be mildly stimulated by mechanical pumping (Gurtz and Weiss 1972).

PREVIOUS STUDIES AT THE COOK PLANT

In response to the above possible alterations of the phytoplankton community in the vicinity of the power plant, two major studies were initiated. The first study, begun in 1968, is directed at determining the long-term effect of the plant on the phytoplankton. This study includes the counting and identification of phytoplankton species at both plant-influenced and non-influenced sites. These data have been used to establish pre-operational phytoplankton trends and variations in the lake against which operational data can be compared. The results of these studies have been reported by Ayers et al. (1970), Ayers et al. (1971), Ayers et al. (1972), Ayers and Seibel (1973), Ayers et al. (1974), Ayers and Kopczynska (1974), Ayers (1975a), Ayers (1975b), Ayers et al. (1977), Ayers (1978), and Ayers and Wiley (1979).

The second study is to ascertain the immediate effect of the plant on the entrained phytoplankton and to monitor long-term changes in the phytoplankton community. Studies pertaining to entrained phytoplankton at the Donald C. Cook Nuclear Plant began in 1975 and continued through May 1982. Results of this study for 1979 are presented here. The monitoring results for 1975, 1976, 1977, and 1978 are found in Rossmann et al. (1977), Rossmann et al. (1979), Rossmann et al. (1980), and Chang et al. (1981), respectively.

SAMPLE HANDLING AND ANALYSIS

Investigation of plant impact on phytoplankton viability, abundance, and species composition was made in accordance with the Environmental Technical Specifications for the plant. Sampling was conducted on a monthly basis with three approximately one-half hour sampling periods in a 24-hour span: after evening twilight, before morning twilight, and at noon. During each sampling period, fourteen samples were collected; seven from the intake forebay and seven from the discharge forebay (Figure 1). Two of the seven samples were preserved for microscopic investigation of phytoplankton abundance and species composition. The remaining five samples were used for spectrophotometric determination of chlorophylls a, b, and c and phaeophytin a. During the first evening sampling period, five additional samples were collected from both the intake and discharge forebays. These samples were incubated at the intake temperature for approximately 36 hours and treated in the same manner as non-incubated samples for analysis of the chlorophylls and phaeophytin a. Samples for nutrient analyses were collected in triplicate from the intake forebay during the noon sampling period.

Throughout 1979, samples were collected at intake grate MTR 1-5 from a depth of 5.5 m. Occasionally, samples were collected at MTR1-4 in the event of a sample pump failure at MTR1-5. Water was collected by diaphragm pumps from the intake and discharge forebays through 3-inch hoses at a rate of roughly 227 L/min. As the water was pumped, the intake and discharge water temperatures were measured, and samples were collected in 1-L polyethylene bottles. Because unit #1 uses 2.7×10^6 L/min for cooling, the samples collected during a one-half hour sampling time represent, for the chlorophyll a and for microscopic

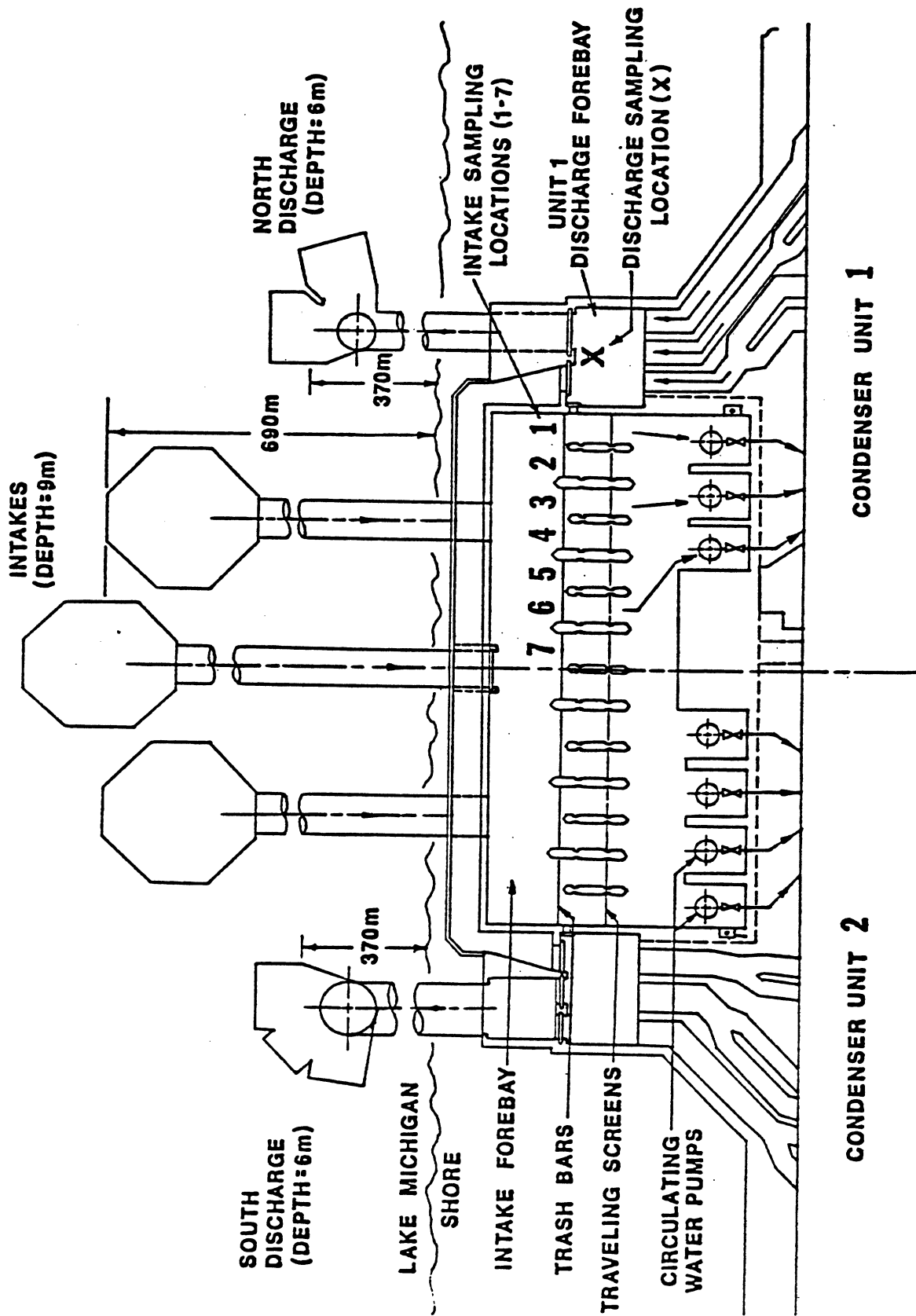


FIG. 1. Sampling locations in the Donald C. Cook Nuclear Plant screenhouse.

phytoplankton analyses, approximately $6.2 \times 10^{-6}\%$ and $2.5 \times 10^{-6}\%$ of the water passing through the plant, respectively. During two unit operation, 6.2×10^6 L/min of water are used for cooling. Thus chlorophyll samples represent $2.7 \times 10^{-6}\%$ and phytoplankton samples represent $1.1 \times 10^{-6} \%$ of the water passing through the plant.

PHYTOPLANKTON

Phytoplankton samples were collected from both the intake and discharge forebays (Figure 1). They were, for the most part, collected in duplicate in 1-L brown polyethylene bottles (triple rinsed with lake water) and immediately fixed with 6 mL of Lugols' iodine solution. Slide preparation was similar to the settle-freeze method of Sanford et al. (1969). One-liter samples were settled in graduated cylinders for 2 days, after which time 900 mL of supernatant were siphoned off. The remaining 100 mL were then agitated to resuspend the settled matter, and 18 mL were poured into a cylindrical plexiglass settling chamber with a microscope slide at its base. Various dilutions were used to facilitate enumeration and identification when there were high concentrations of suspended material. The chambers were secured to the slides with a minimal amount of stopcock grease on their ends, and the chamber-slide combinations were clamped onto a one-quarter-inch thick aluminum plate. After 2 days of settling, freezing of the bottom 2 to 3 mm (0.5 to 0.7 mL) was accomplished by placing the entire apparatus on a block of dry ice for approximately 25 seconds. The supernatant was poured off and, when the ice at the bottom of the chamber had melted sufficiently, the cylinder was removed from the slide, and the slide with its thin wafer of ice and water was dehydrated in an anhydrous alcohol chamber for 2 days. This was followed by 2 days in a

toluene chamber to prepare the sample for permanent mounting under a cover slip in Permunt.

All counting was done on Leitz Ortholux and Dialux microscopes at 1,000 to 1,250X. Identification of specimens was carried to species and variety when possible. Enumeration was in cells per milliliter except for blue-green filaments with cylindrical trichomes which were in filaments per milliliter. Two complete 100 μ m wide transects were made across each slide, one horizontal and one vertical, to help offset patchiness in distribution. A minimum of 500 cells was counted for each slide to ensure reasonable group percentages; more transects and/or higher counts were necessary if a fairly large number or proportion of the cells were in colonial formations.

CHLOROPHYLLS AND PHAEOPHYTIN a

Immediately after collection, each 1-L water sample was passed through a 4.25-cm diameter Whatman GF/C glass fiber filter. After most of the water had passed through the filter, 1 mL of saturated MgCO_3 was added (1 g $\text{MgCO}_3 \cdot 4\text{H}_2\text{O}$ /100 g distilled water). The measuring flask and filtration apparatus were rinsed with distilled water. Following filtration, the filters were rolled with forceps, placed in amber vials, frozen, and transported to Ann Arbor. The samples selected for incubation were not filtered at the time of collection but were immediately placed in an incubator with the bottle caps removed and allowed to incubate in the dark for 24 to 48 hours at the intake temperature. Following this, they were filtered and treated in the same manner as the non-incubated samples.

In the Ann Arbor laboratory, the frozen samples were prepared for analysis by grinding with a tissue grinder and extracting into 90% acetone using the

method of Strickland and Parsons (1972). The 90% acetone was prepared by swirling reagent grade acetone with anhydrous Na_2CO_3 and passing it through a Whatman #4 filter (containing some additional Na_2CO_3) into a volumetric flask having the appropriate volume of distilled water for a 90% solution (v/v). Sample vials were removed from the freezer in groups of five and placed on ice in a dark ice chest next to the grinding apparatus. Sample vials were removed one at a time from the ice chest, and the frozen filters were transferred with forceps to a tissue grinding tube immersed in an icebath. The filter was ground at approximately 100 rpm for 4 minutes in 1.5 to 2 mL of 90% acetone in a tissue grinding tube; the grinding tube was held firmly against the rotating pestle, lowered briefly, and raised back against the pestle approximately every 15 seconds. If the filter and 90% acetone were not reduced to a homogeneous slurry after 4 minutes, grinding was continued until this was accomplished, generally within 1 minute. The contents of the grinding tube were then poured into a 12-mL screw cap centrifuge tube. The tissue grinder was rinsed three times with 90% acetone into the centrifuge tube to adjust the final volume of 90% acetone to 10 mL. The centrifuge tube was then capped and returned to the ice chest. After all five samples were ground, they were placed in a dark refrigerator and allowed to extract for 24 to 36 hours. Following extraction, each sample was inverted three times, packed in ice, and centrifuged for 4 minutes at 2,000 rpm to separate the filter fibers and MgCO_3 from the extract. The centrifuged samples were then refrigerated until shortly before analysis.

For analysis, individual samples were warmed to room temperature in a light tight container. The extract was transferred using a Pasteur pipette to two 5-cm-path long cuvettes. Two drops of 50% v/v HCl were added to the sample in one cuvette, which was shaken and then held for 4 minutes. The other cuvette

was placed in a Beckman model 25 scanning spectrophotometer where sample absorbances were measured between 600 and 750 nm. The absorbance of the acidified sample was then measured over the same range.

NUTRIENTS

During 1979, samples for nutrient analyses were collected in triplicate from the intake forebay of the plant at location MTR 1-5. Collection coincided with the noon sampling period for phytoplankton. Each sample was analyzed for orthophosphate, nitrate, nitrite, and dissolved reactive silica. The methodology used is described in Rossmann et al. (1979) and the quality control is described in Rossmann et al. (1980).

CONDITIONS AT TIME OF COLLECTION

TEMPERATURE AND PHYSICAL EVENTS

Table 1 contains a summary of intake and discharge temperatures for those periods of time when phytoplankton entrainment samples were collected. Sampling did not occur in June because the plant was not operational and on September 10 at evening twilight because the sampling pump broke.

During October, phytoplankton collection coincided with large, rapid temperature changes resulting from the upwelling of colder bottom water along the eastern shore of Lake Michigan in the vicinity of the Donald C. Cook Nuclear Plant. Similar events took place the week preceding the September entrainment collection. Upwelling transports cold bottom water, rich in nutrients and containing its own phytoplankton assemblage, to nearshore regions of the lake. Mixing of cold bottom water with warmer surface water yields a water mass having

TABLE 1. Intake and discharge entrainment temperatures at the time of sampling during 1979.

<u>Date</u>	<u>Time</u>	<u>Intake</u> °C	<u>Discharge</u> #1, °C	<u>Discharge</u> #2, °C
January 8, 1979	Morning Twilight	1.0	13.5	11.8
9	Noon	1.8	14.0	12.0
9	Evening Twilight	1.2	14.5	16.0
February 12, 1979	Evening Twilight	6.2	17.0	15.6
13	Morning Twilight	6.2	16.8	16.2
13	Noon	6.8	17.0	16.5
March 5, 1979	Evening Twilight	0.5	13.5	10.2
6	Morning Twilight	6.2	17.8	15.8
6	Noon	5.2	17.2	15.5
April 9, 1972	Evening Twilight	3.2	--	12.5
10	Morning Twilight	3.2	--	11.8
10	Noon	3.5	--	12.3
May 7, 1979	Evening Twilight	10.0	--	20.8
8	Morning Twilight	10.1	--	20.9
8	Noon	10.8	--	21.2
June 12, 1979	Evening Twilight	--	--	--
13	Morning Twilight	--	--	--
13	Noon	--	--	--
July 10, 1979	Evening Twilight	16.7	--	25.8
10	Morning Twilight	17.0	--	25.8
10	Noon	18.0	--	26.6
August 6, 1979	Evening Twilight	24.5	35.0	34.0
7	Morning Twilight	24.0	34.2	34.0
7	Noon	24.3	35.5	34.0
September 10, 1979	Evening Twilight	19.8		29.2
11	Morning Twilight	19.8	31.0	29.6
11	Noon	21.0	31.1	30.2
October 8, 1979	Evening Twilight	16.0	27.2	25.0
9	Morning Twilight	16.0	27.0	24.5
9	Noon	15.0	26.0	24.0
November 12, 1979	Evening Twilight	9.5	19.8	--
13	Morning Twilight	9.3	19.9	--
13	Noon	9.3	20.2	--
December 10, 1979	Evening Twilight	4.0	18.0	--
11	Morning Twilight	4.1	17.5	--
11	Noon	4.1	17.2	--

*Dashes appear when a unit was not operating. Blanks are for missing data.

characteristics of each and results in an increased sample heterogeneity; thus when the upwelling occurs during a sampling period, the sampling error increases.

CHLORINATION

Previous to 1979, chlorination occurred twice daily at the Donald C. Cook Nuclear Plant. Chlorination ceased at the Cook Plant at the end of 1978.

RESULTS AND DISCUSSION

NUTRIENTS

Concentrations of orthophosphate, nitrate, nitrite, and dissolved reactive silica varied throughout the year in response to upwelling, storm events, and utilization by the phytoplankton (Table 2). Nitrite was detectable during April, May, June, and December. During October, sample collection coincided with large temperature changes due to upwelling of colder bottom water along the eastern shore of Lake Michigan in the vicinity of the Donald C. Cook Nuclear Plant. This upwelling increased the dissolved silica concentration to 1.1 ppm. Dissolved silica decreased dramatically in May following the centric diatom spring peak and coinciding with the pennate diatom spring peak. The dissolved silica concentration increased in October in response to an upwelling. Dissolved silica concentrations were low again in December, signalling commencement of the winter pennate diatom bloom.

TABLE 2. Monthly variation of nutrients during 1979.¹

Month	Orthophosphate PO ₄ -P, ppb		Nitrate-N, ppm		Nitrite-N, ppm		SiO ₂ , ppm	
January	.85	(.26)	.13	(.050)	0.0	(0.0)	1.3	(.10)
February	.080	(.024)	.14	(.0093)	0.0	(0.0)	1.3	(.14)
March	.63	(.17)	.065	(.010)	0.0	(0.0)	2.0	(.17)
April	2.7	(.68)	.32	(.0022)	.0046	(.0080)	1.9	(.053)
May	.97	(.19)	.15	(0.019)	.014	(.0040)	.017	(.0091)
June	2.1	(.24)	.14	(.063)	.0048	(.0014)	1.6	(.047)
July	1.2	(.030)	.20	(.014)	0.0	(0.0)	.56	(.040)
August	1.0	(.54)	.16	(.0080)	0.0	(0.0)	.42	(.13)
September	3.2	(.30)	.16	(.00072)	0.0	(0.0)	.37	(.091)
October	.61	(.040)	.21	(.014)	0.0	(0.0)	1.1	(.051)
November	4.2	(.68)	.18	(.031)	0.0	(0.0)	.78	(.18)
December	.24	(.088)	.26	(.0052)	.0076	(.0019)	.25	(.098)

¹Means are followed by standard deviations in parentheses.

PHYTOPLANKTON

Monthly Variations of Entrained Major Phytoplankton Groups

The major groups of phytoplankton under consideration are coccoid blue-green algae, filamentous blue-green algae, coccoid green algae, filamentous green algae, flagellates, centric diatoms, pennate diatoms, desmids, and other algae. With the exception of the desmids, whose population level is relatively low throughout the year, all major groups represent significant contributions to the composition of the total algal assemblage. The succession of diatoms, blue-green algae, green algae, and flagellates is of importance in this system (Rossmann et al. 1979). In general, these annual succession patterns are predictable year after year and are summarized in the paragraphs which follow.

Diatoms contribute the largest numbers to the total annual algal assemblage and include two major groups: centric and pennate diatoms. These groups, which have a close ecological affinity, are relatively abundant in spring (Rossmann et al. 1977, 1979, 1980). They usually reach their peak in April and decrease thereafter. This decrease in abundance after April is most frequently related to the onset of thermal stratification which isolates the surface waters from the pool of nutrients in the hypolimnion. At the same time, increases in diatoms accelerate the utilization of nutrients and result in nutrient depletion, especially depletion of dissolved silica, which is an essential element for diatom growth. The resulting low population density continues until October when a decrease in water temperature and physical mixing processes create an isothermal water column. During the establishment of an isothermal water column, nutrients such as dissolved silica are replenished, leading to a relatively high density of diatoms throughout the winter months.

The green algae population, including coccoid green and filamentous green algae, is generally low from January through May or June. It reaches a peak density during the warm water months of May through September, and then declines during October through December.

Blue-green algae are low in concentration from January through April for the filamentous and from January through July for the coccoid. Population abundance is highest during June through October when water temperatures are relatively high, and its abundance decreases in November and December with decreased water temperature.

Flagellates are relatively low in concentration during January through March. A population peak generally occurs in April or May, and a large population often continues through December.

The patterns of succession described above serve as a general temporal distribution of species occurring in the offshore waters of Lake Michigan, but they are seldom completely coincident with the species found in the nearshore region of Lake Michigan where environmental factors dominating the system vary greatly from year to year in degree and in time of occurrence. Furthermore, in the case of the entrainment samples, thermal effluents from the power generating plant offer an additional variable which may cause further deviations from the described patterns of succession. Because the general pattern of succession does not fully describe the existing yearly variations, it would be of benefit to look at the observed patterns of 1979 algal succession. The complete results of microscopic counting of the 1979 phytoplankton entrained are in the Appendix.

In 1979, coccoid blue-green algae population density reached a maximum in August (Table 3 and Figure 2). Comparisons between the total abundance of the coccoid blue-green in 1979 with those in 1975, 1976, 1977, and 1978 indicate a

TABLE 3. Monthly variation of coccoid blue-green algae from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	461.(149)			296.0(91.8)	274.(44.4)
February	109.(59.7)	254.(71.7)		95.0(50.0)	119.(24.3)
March	257.(186.)	347.(110.)	137.(57.2)	28.7(12.6)	208.(43.7)
April	312.(125.)	143.(63.6)	110.(76.2)	78.8(30.7)	29.8(27.5)
May	689.(169.)	87.1(46.6)	47.3(27.3)	143.(54.5)	171.(137.)
June	235.(155.)	33.6(25.1)	114.(45.6)	521.(166.)	
July	1,050.(155>)	57.8(26.5)	133.(28.5)	244.(75.7)	117.(27.6)
August	286.(53.2)	439.(93.8)	1,210.(254.)	149.(35.4)	376.(53.1)
September	1,220.(169.)	339.(118.)	917.(93.6)	660.(80.4)	845.(138.)
October	945.(212.)	560.(196.)	727.(145.)	2,353.(365.)	1,209.(142.)
November	600.(166.)	422.(121.)	1,320.(289.)	1,992.(278.)	1,013.(119.)
December	<u>176.(106.)</u>	<u>275.(73.4)</u>	<u>872.(124.)</u>	<u>3,642.(363.)</u>	<u>1,282.(174.)</u>
Yearly Mean	535.(117.)	285.(50.1)	559.(159.)	850.(134.)	513.(144.)

* Mean is followed by the standard error.

COCCOID BLUE-GREEN ALGAE

MEANS AND STANDARD ERRORS

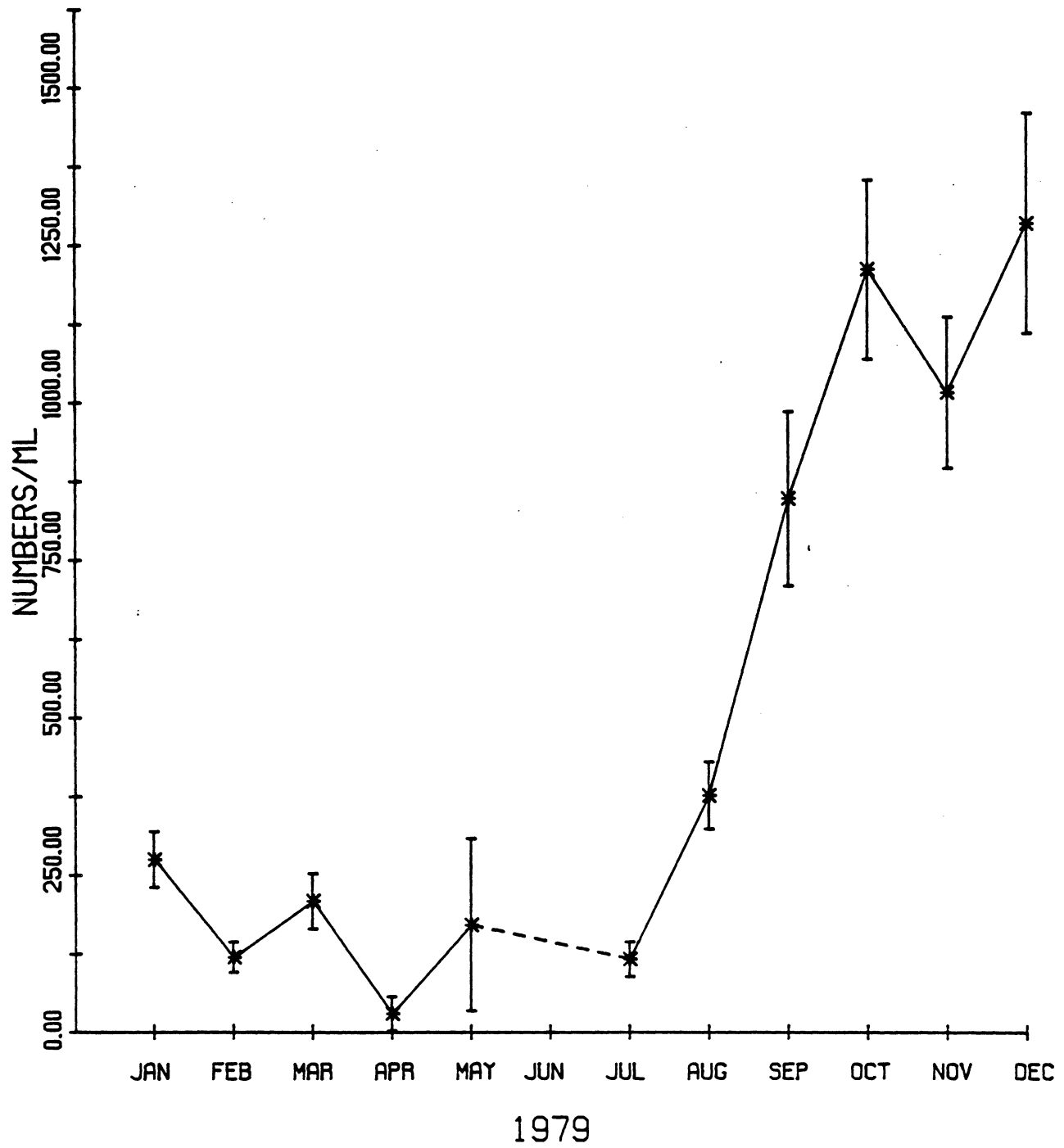


FIG. 2. Variation of coccoid blue-green algae numbers during 1979.

marked decrease with respect to 1975, 1976, and 1978, but an increase with respect to 1977.

Filamentous blue-green algae were less numerous than coccoid blue-green algae and peaked in July and October of 1979 (Table 4 and Figure 3). Their abundance in 1979 was greater than that of 1977 and less than those of 1975, 1976, and 1978.

In 1979, coccoid green algae abundances peaked in May, August, October, and December (Table 5 and Figure 4). The mean population was quite variable between 1975 and 1979. There was an increase in mean population density between 1975 and 1976, a decrease between 1976 and 1977, an increase between 1977 and 1978, and a decrease between 1978 and 1979.

Filamentous green algae were less numerous than coccoid green algae and had a population density above 10 cells/mL only in December 1979 (Table 6 and Figure 5). The 1979 yearly average of this group is the lowest for the years 1975 through 1979.

Flagellates were numerous and contributed a large portion to the total annual algal population in 1979 (Table 7 and Figure 6). They had a relatively high density in May and July, reached their peak in May, and maintained a rather low density during the rest of the year. The May peak, however, might not be the true maximum for 1979, as past data indicate that the June sample (which was not collected in 1979 because the plant was not operating) usually shows a very high density of flagellates. For the same reason, the yearly average for 1979 may be an overly low value. This should be kept in mind in evaluating the finding that the 1979 yearly average of abundance is the lowest among the years surveyed.

In 1979, centric diatoms were relatively low in abundance in early spring,

TABLE 4. Monthly variation of filamentous blue-green algae from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January		22.0(8.06)		15.2(5.61)	7.92(1.33)
February	28.2(8.10)	16.4(3.53)		6.22(2.46)	3.78(0.60)
March	59.7(17.6)	13.4(2.53)	16.7(3.19)	3.60(.921)	4.57(0.86)
April	27.6(5.40)	57.9(5.16)	110.(76.2)	2.63(.919)	3.58(1.71)
May	103.(37.0)	457.(52.8)	17.5(4.09)	14.5(4.52)	15.5(5.63)
June	314.(38.1)	81.1(16.1)	24.3(8.29)	111.(51.9)	
July	95.1(25.5)	72.1(12.7)	59.9(14.3)	65.0(12.6)	201.(29.3)
August	8.90(2.70)	9.24(3.08)	17.6(6.37)	111.(26.5)	20.1(5.09)
September	17.3(9.20)	46.8(15.8)	25.0(8.84)	8.89(2.68)	41.8(5.81)
October	98.8(34.0)	45.9(23.8)	21.4(7.61)	87.0(18.9)	115.(18.2)
November	21.6(17.8)	6.35(4.31)	12.7(3.13)	82.9(18.7)	38.3(9.60)
December	<u>15.4(7.70)</u>	<u>74.5(44.3)</u>	<u>45.2(18.6)</u>	<u>67.9(13.5)</u>	<u>5.38(1.91)</u>
Yearly Mean	71.8(26.5)	75.2(35.6)	35.0(9.54)	48.0(13.3)	41.5(18.7)

* Mean is followed by the standard error.

FILAMENTOUS BLUE-GREEN ALGAE

MEANS AND STANDARD ERRORS

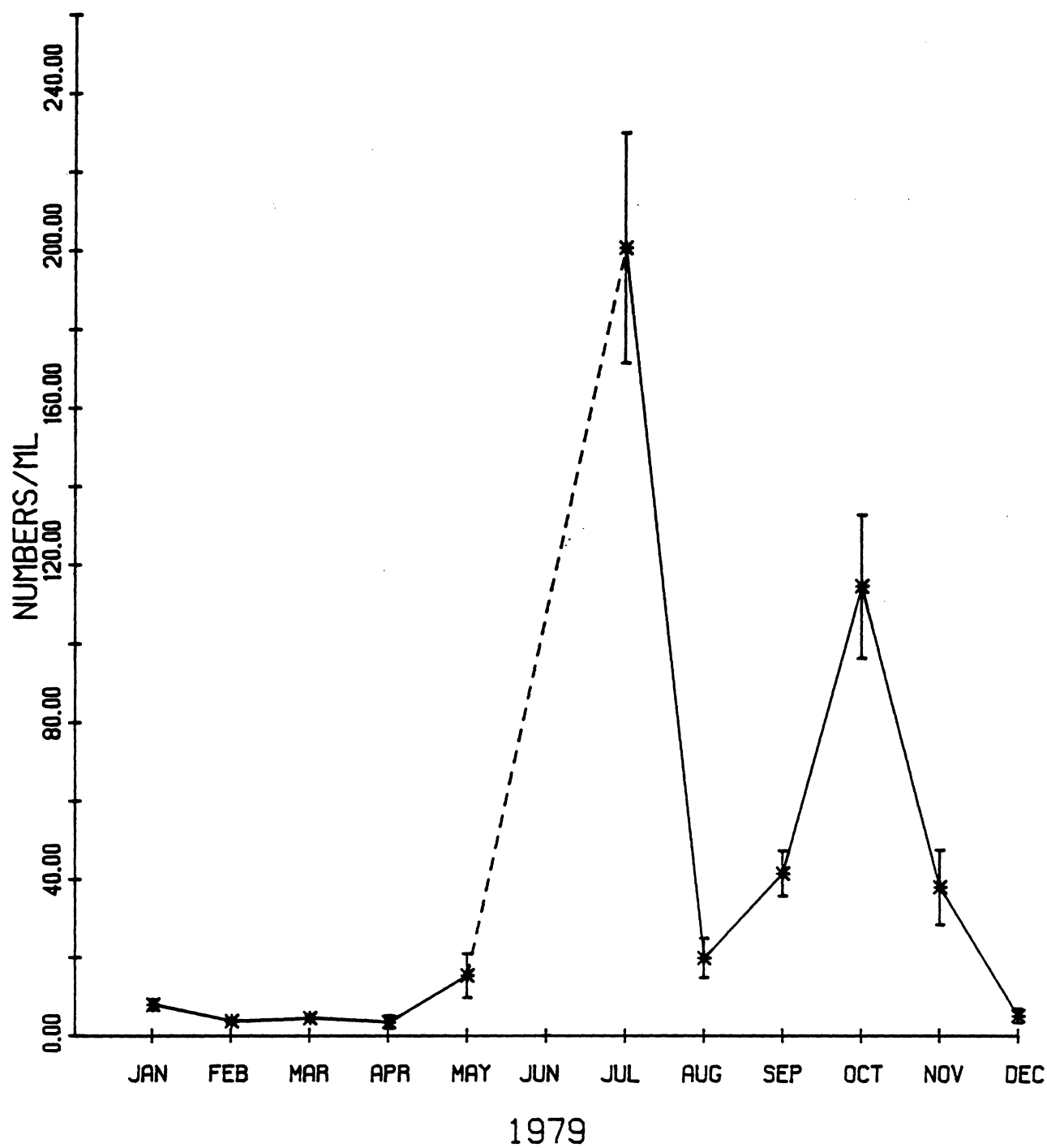


FIG. 3. Variation of filamentous blue-green algae numbers during 1979.

TABLE 5. Monthly variation of coccoid green algae from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	42.2(12.2)			56.8(17.4)	39.6(4.87)
February	39.3(14.2)	29.5(11.1)		10.7(2.57)	18.5(3.53)
March	55.2(24.7)	22.9(7.63)	21.1(4.43)	16.6(4.54)	79.4(43.5)
April	49.7(14.8)	57.9(12.3)	51.4(8.31)	108.(25.2)	69.9(22.4)
May	47.1(19.7)	145.(30.6)	15.3(4.89)	145.(23.6)	125.(18.1)
June	141.(23.2)	98.4(26.9)	39.2(15.8)	150.(45.3)	
July	1,000.(107.)	689.(123.)	152.(19.2)	103.(35.9)	54.9(15.2)
August	197.(37.1)	494.(46.8)	115.(16.5)	166.(32.9)	153.(21.6)
September	176.(24.2)	755.(129.)	54.4(8.31)	174.(24.1)	95.6(10.6)
October	116.(16.1)	242.(37.1)	232.(85.4)	256.(26.9)	132.(12.9)
November	138.(66.9)	134.(36.1)	65.1(18.2)	159.(18.1)	77.9(15.0)
December	<u>110.(47.8)</u>	<u>249.(54.5)</u>	<u>49.5(11.4)</u>	<u>194.(15.1)</u>	<u>133.(29.9)</u>
Yearly Mean	188.(82.8)	246.(74.6)	79.5(21.5)	128.(22.6)	89.0(12.9)

* Mean is followed by the standard error.

COCCOID GREEN ALGAE

MEANS AND STANDARD ERRORS

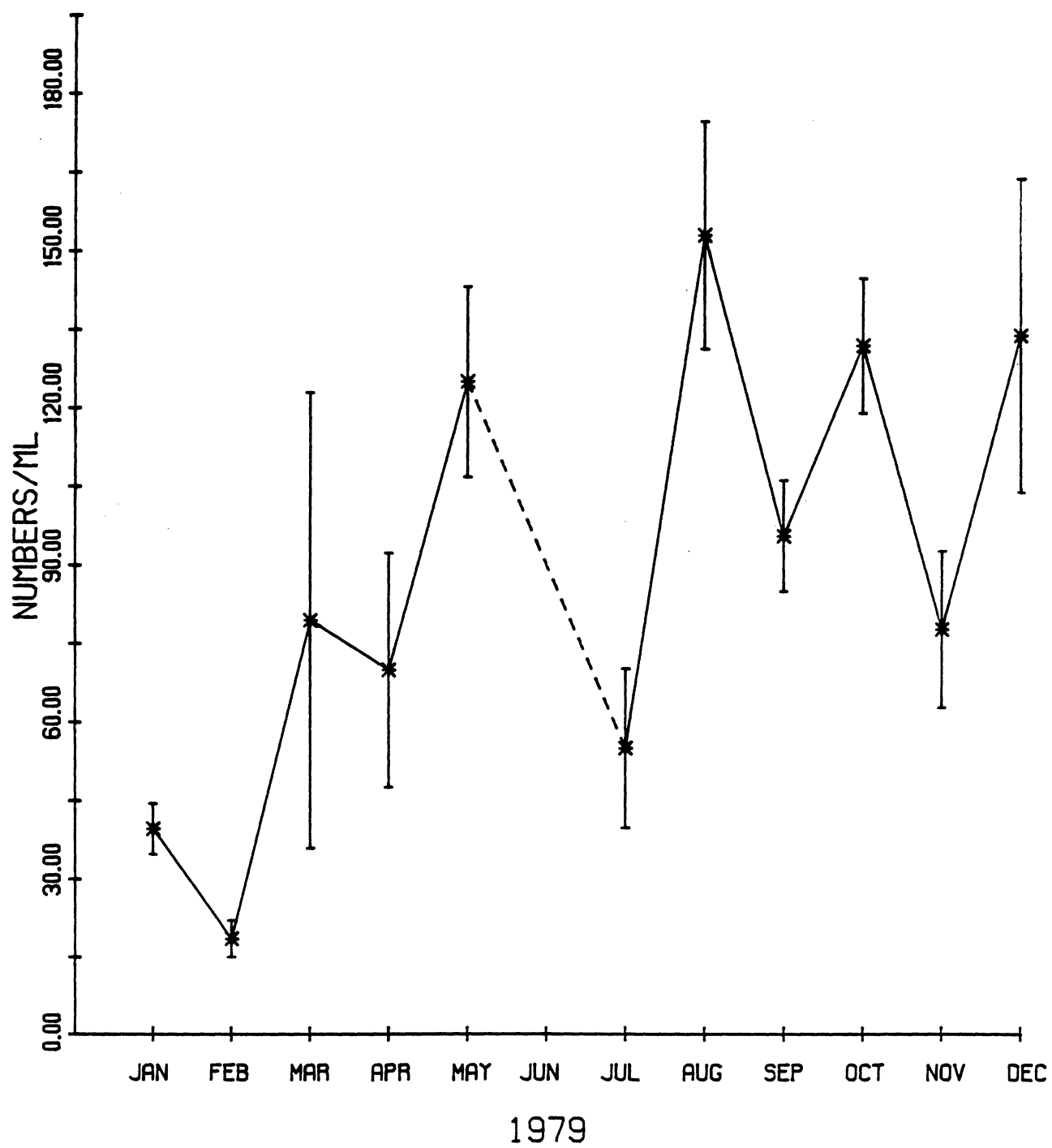


FIG. 4. Variation of coccoid green algae numbers during 1979.

TABLE 6. Monthly variation of filamentous green algae from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	31.6(17.4)			2.26(1.35)	2.49(0.89)
February	18.0(9.70)	2.00(1.20)		.350(.241)	.278(0.278)
March	34.8(12.6)	16.4(6.62)	6.63(4.37)	3.04(1.82)	.600(0.328)
April	0.0(0.0)	18.1(10.5)	18.2(12.3)	2.21(1.70)	0.0(0.0)
May	1.50(1.50)	57.8(23.0)	4.63(2.32)	1.70(1.15)	0.0(0.0)
June	29.5(20.6)	55.0(14.0)	.417(.417)	2.6(1.03)	
July	0.3(0.3)	37.3(11.1)	22.9(4.79)	11.2(2.81)	4.34(1.40)
August	0.8(0.6)	4.28(2.52)	0.0(0.0)	8.15(2.83)	.228(0.228)
September	0.2(0.2)	13.7(6.13)	1.86(.888)	1.12(.401)	.700(0.523)
October	2.8(1.1)	9.67(2.47)	6.63(4.02)	8.19(2.16)	5.53(1.61)
November	1.5(1.2)	6.35(5.48)	26.8(6.92)	18.4(4.37)	0.0(0.0)
December	<u>14.4(7.3)</u>	<u>5.52(2.39)</u>	<u>14.0(6.97)</u>	<u>35.8(4.55)</u>	<u>12.3(7.81)</u>
Yearly Mean	9.44(3.87)	21.5(5.64)	10.2(3.06)	7.92(2.03)	2.41(1.14)

* Mean is followed by the standard error.

FILAMENTOUS GREEN ALGAE

MEANS AND STANDARD ERRORS

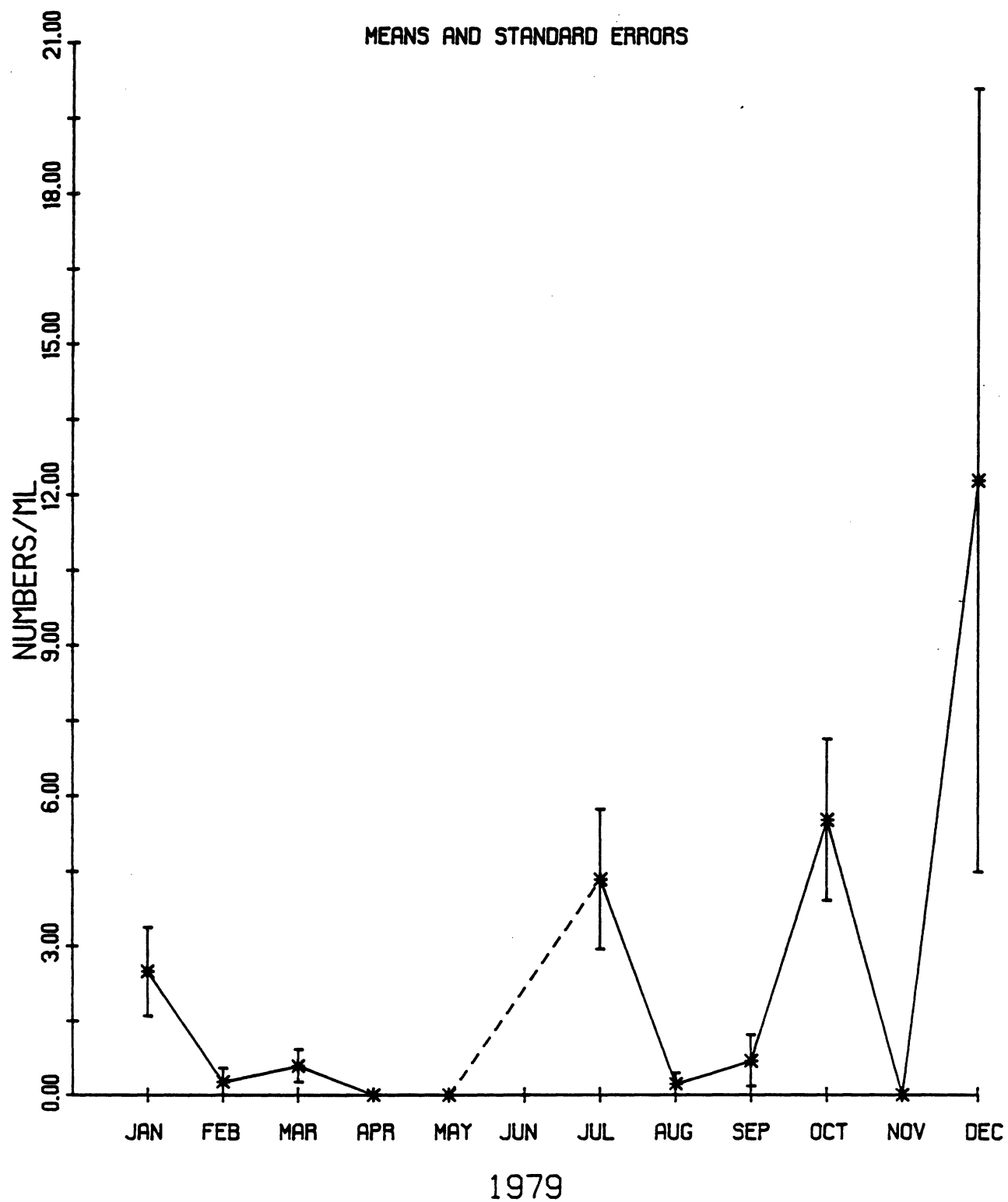


FIG. 5. Variation of filamentous green algae numbers during 1979.

TABLE 7. Monthly variation of flagellated algae from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	110.(18.7)			156.(44.0)	278.(53.2)
February	90.8(20.8)	252.(32.1)		109.(21.7)	241.(46.6)
March	272.(56.6)	268.(25.5)	628.(60.2)	97.5(24.6)	392.(37.1)
April	857.(190.)	351.(36.6)	1,010.(116.)	435.(69.9)	379.(44.4)
May	641.(82.3)	1,350.(220.)	1,200.(160.)	728.(167.)	625.(80.5)
June	802.(148.)	633.(70.5)	235.(30.6)	2,838.(275.)	
July	561.(94.6)	452.(31.6)	267.(33.9)	395.(77.7)	534.(51.4)
August	504.(56.7)	482.(86.8)	376.(31.9)	191.(18.9)	227.(34.9)
September	587.(71.6)	426.(70.3)	302.(57.8)	75.7(11.5)	274.(38.7)
October	696.(85.4)	559.(91.7)	550.(91.8)	108.(15.9)	249.(34.9)
November	417.(51.9)	524.(47.6)	754.(156.)	52.0(12.4)	444.(29.4)
December	<u>368.(59.9)</u>	<u>415.(84.2)</u>	<u>78.9(19.3)</u>	<u>261.(88.0)</u>	<u>486.(66.0)</u>
Yearly Mean	527.(69.0)	485.(89.0)	540.(114.)	454.(68.9)	375.(40.5)

* Mean is followed by the standard error.

FLAGELLATES

MEANS AND STANDARD ERRORS

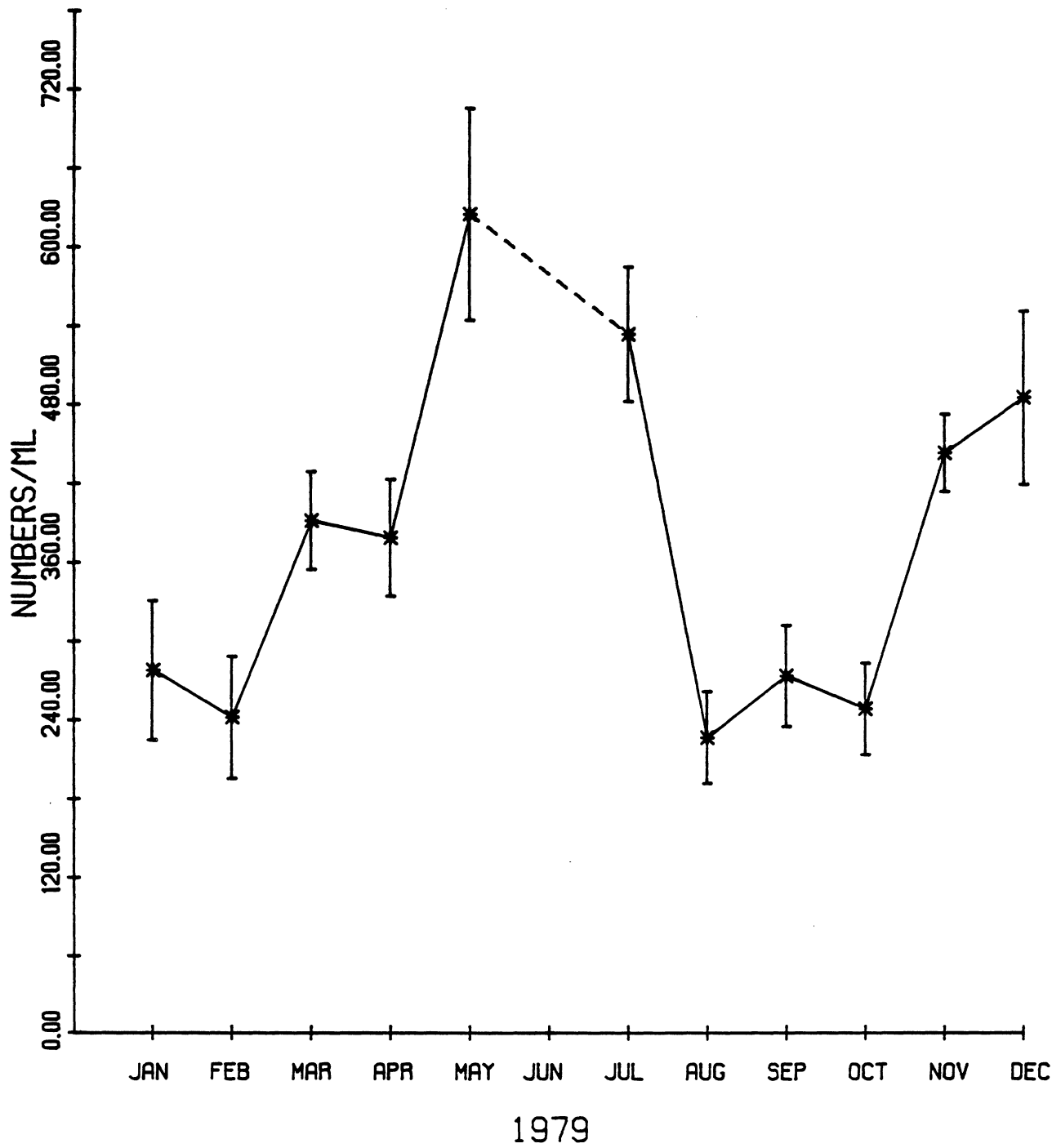


FIG. 6. Variation of flagellated algae numbers during 1979.

reached a population peak in April, and decreased thereafter (Table 8 and Figure 7). The population remained relatively low throughout the rest of the year except during October. The June population, which is often high, was not collected in 1979. As a result, the yearly average of centric diatoms may be unduly low. Based on available data, mean population density was higher than that of 1977, but was lower than that of 1975, 1976, and 1978.

Pennate diatoms contributed a large share to the total algal population in 1979 (Table 9 and Figure 8). They were low in density in spring, reached a peak in May, and decreased in July through October. The population density remained low until November when thermal stratification ceased. As no sample was collected in June 1979, the value for the yearly average may be unduly low. Therefore, the reduction in mean annual density for 1979 relative to previous sampling years may in part be due to the absence of June data.

Desmids were consistently low in abundance throughout 1979 (Table 10 and Figure 9). The maximum population density did not exceed 3 cells/mL; the peak was in May. No significant change in population was found from 1975 to 1979.

The group of "other algae" is composed of phytoplankton which can not be identified adequately to be placed in any of the groups mentioned above. Most algae in this group are green algae. In 1979, this group of phytoplankton reached peaks of abundance in May, August, and October (Table 11 and Figure 10). The population maximum was found in October. The 1975 mean population density was the lowest in the period from 1975 through 1979.

In 1979, total phytoplankton abundance reached peaks in April-May, October, and December (Table 12 and Figure 11). The maximum was during April and May and corresponded with maximums of centric and pennate diatoms, respectively. High population peaks were also encountered in October and December after isothermal

TABLE 8. Monthly variation of centric diatoms from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	1,810.(191.)			310.(46.7)	193.(11.6)
February	1,040.(130.)	560.(45.0)		125.(12.8)	169.(8.95)
March	1,290.(111.)	807.(56.8)	463.(57.7)	423.(37.8)	352.(22.1)
April	2,550.(427.)	930.(51.1)	779.(83.9)	592.(74.5)	2,590.(199.)
May	1,190.(170.)	1,400.(189.)	139.(23.1)	1,797.(167.)	428.(28.4)
June	817.(64.3)	212.(18.3)	451.(91.5)	1,448.(140.)	
July	914.(108.)	3,370.(361.)	967.(65.9)	1,101.(99.5)	78.8(6.89)
August	102.(23.9)	272.(25.9)	175.(12.0)	197.(29.8)	96.3(9.88)
September	69.2(8.3)	1,060.(157.)	183.(14.8)	225.(40.5)	247.(28.2)
October	286.(21.2)	644.(50.9)	140.(18.1)	904.(88.7)	511.(53.0)
November	404.(64.5)	1,090.(69.4)	194.(24.2)	195.(21.3)	240.(14.3)
December	<u>1,700.(132.)</u>	<u>503.(58.8)</u>	<u>165.(18.5)</u>	<u>160.(9.63)</u>	<u>368.(34.1)</u>
Yearly Mean	945.(224.)	1,050.(249.)	366.(93.7)	623.(64.0)	479.(214.)

* Mean is followed by the standard error.

CENTRIC DIATOMS

MEANS AND STANDARD ERRORS

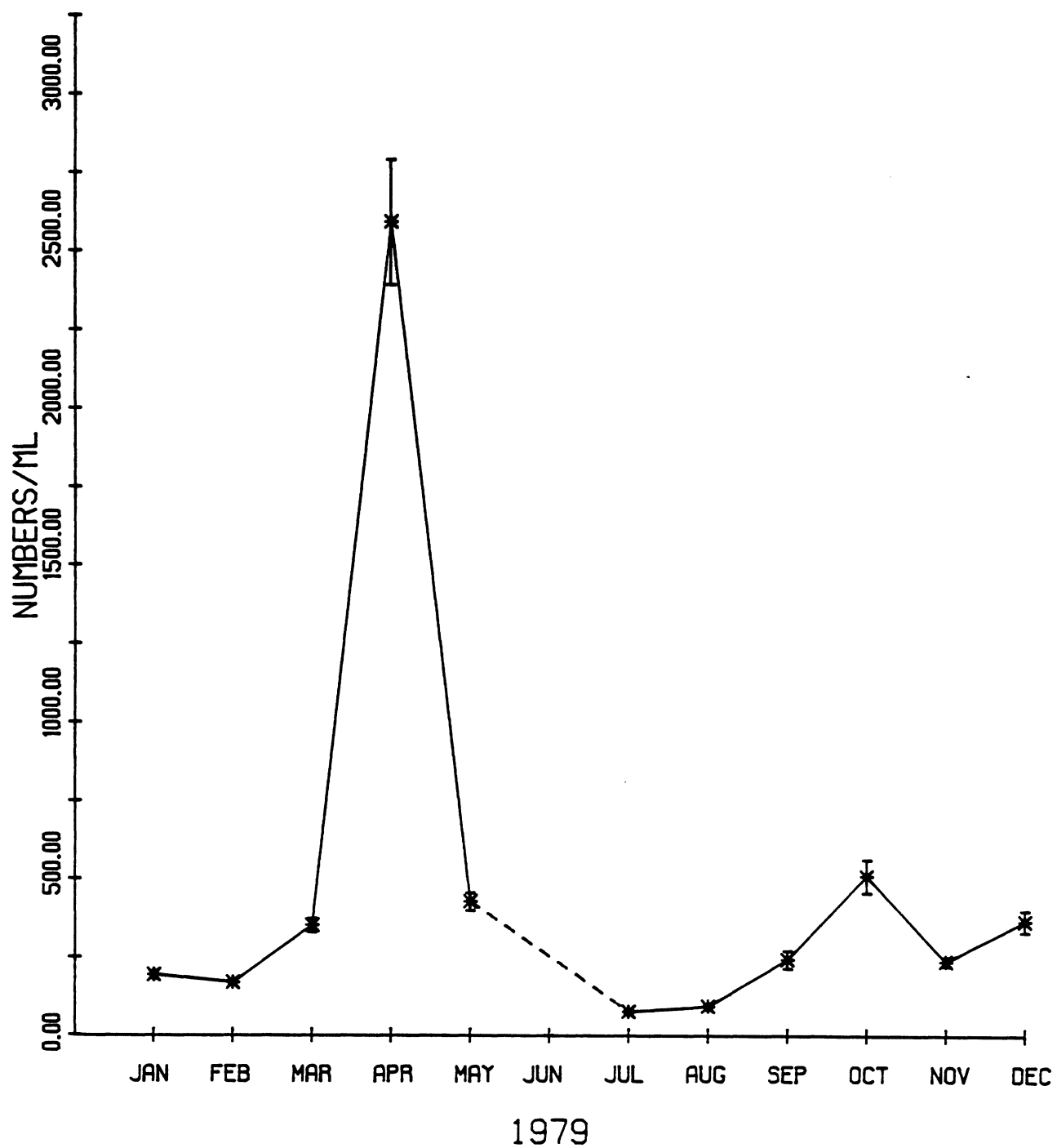


FIG. 7. Variation of centric diatom numbers during 1979.

TABLE 9. Monthly variation of pennate diatoms from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January		991.(186.)		598.(79.0)	213.(16.3)
February	1,640.(196.)	265.(43.0)		62.2(8.27)	43.8(4.29)
March	1,340.(146.)	329.(46.3)	1,210.(90.6)	41.7(4.68)	199.(17.9)
April	1,160.(306.)	1,340.(123.)	1,710.(187.)	226.(37.1)	747.(67.8)
May	3,040.(278.)	864.(158.)	383.(45.0)	1,909.(162.)	2,492.(142.)
June	1,220.(102.)	332.(29.9)	743.(129.)	1,751.(134.)	
July	90.8(12.8)	2,900.(459.)	487.(44.8)	1,448.(160.)	156.(26.7)
August	84.8(16.8)	1,250.(207.)	73.2(10.1)	514.(71.1)	267.(37.2)
September	270.(52.7)	1,920.(411.)	146.(15.5)	120.(23.2)	133.(25.6)
October	295.(34.6)	498.(36.6)	822.(45.2)	570.(63.1)	381.(22.8)
November	501.(74.2)	824.(100.)	724.(100.)	963.(107.)	638.(57.0)
December	<u>333.(43.4)</u>	<u>1,320.(148.)</u>	<u>548.(50.2)</u>	<u>572.(45.5)</u>	<u>1,759.(131.)</u>
Yearly Mean	907.(271.)	1,070.(220.)	685.(155.)	731.(74.6)	639.(236.)

* Mean is followed by the standard error.

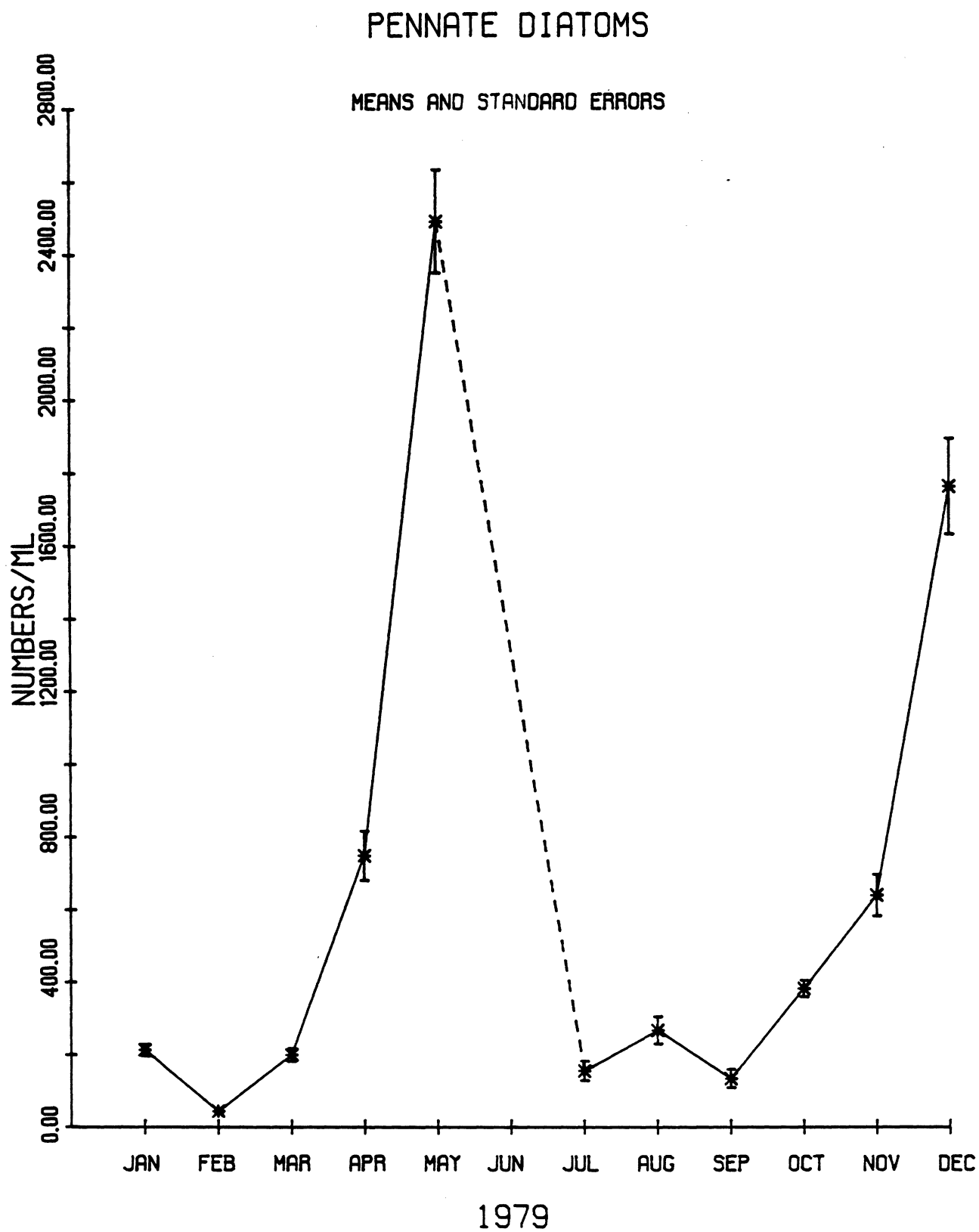


FIG. 8. Variation of pennate diatom numbers during 1979.

TABLE 10. Monthly variation of desmids from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	0.0(0.0)			1.05(.318)	0.461(0.155)
February	0.8(0.5)	.283(.191)		.275(.207)	0.339(0.116)
March	0.8(0.5)	.417(.298)	.142(.142)	.208(.215)	0.322(0.138)
April	1.2(1.2)	.825(.592)	.275(.275)	0.0(0.0)	0.0(0.0)
May	3.0(0.0)	1.65(.642)	1.52(.583)	.833(.435)	2.75(1.06)
June	2.5(0.9)	.142(.142)	1.25(.580)	.825(.431)	
July	2.2(1.2)	1.25(.843)	1.47(.325)	2.38(.696)	0.833(0.308)
August	0.4(0.2)	.550(.371)	1.11(.587)	.511(.225)	0.278(0.166)
September	0.3(0.3)	.275(.275)	.0667(.0667)	.022(.022)	0.231(0.115)
October	0.8(0.4)	0.0(0.0)	0.0(0.0)	1.20(.439)	0.511(0.225)
November	0.5(0.3)	0.0(0.0)	.825(.431)	1.94(.561)	1.11(0.424)
December	<u>0.0(0.0)</u>	<u>.417(.298)</u>	<u>1.38(.604)</u>	<u>1.98(.397)</u>	<u>1.25(0.506)</u>
Yearly Mean	1.14(.298)	.484(.150)	.804(.197)	.935(.329)	0.731(0.233)

* Mean is followed by the standard error.

DESMIDS

MEANS AND STANDARD ERRORS

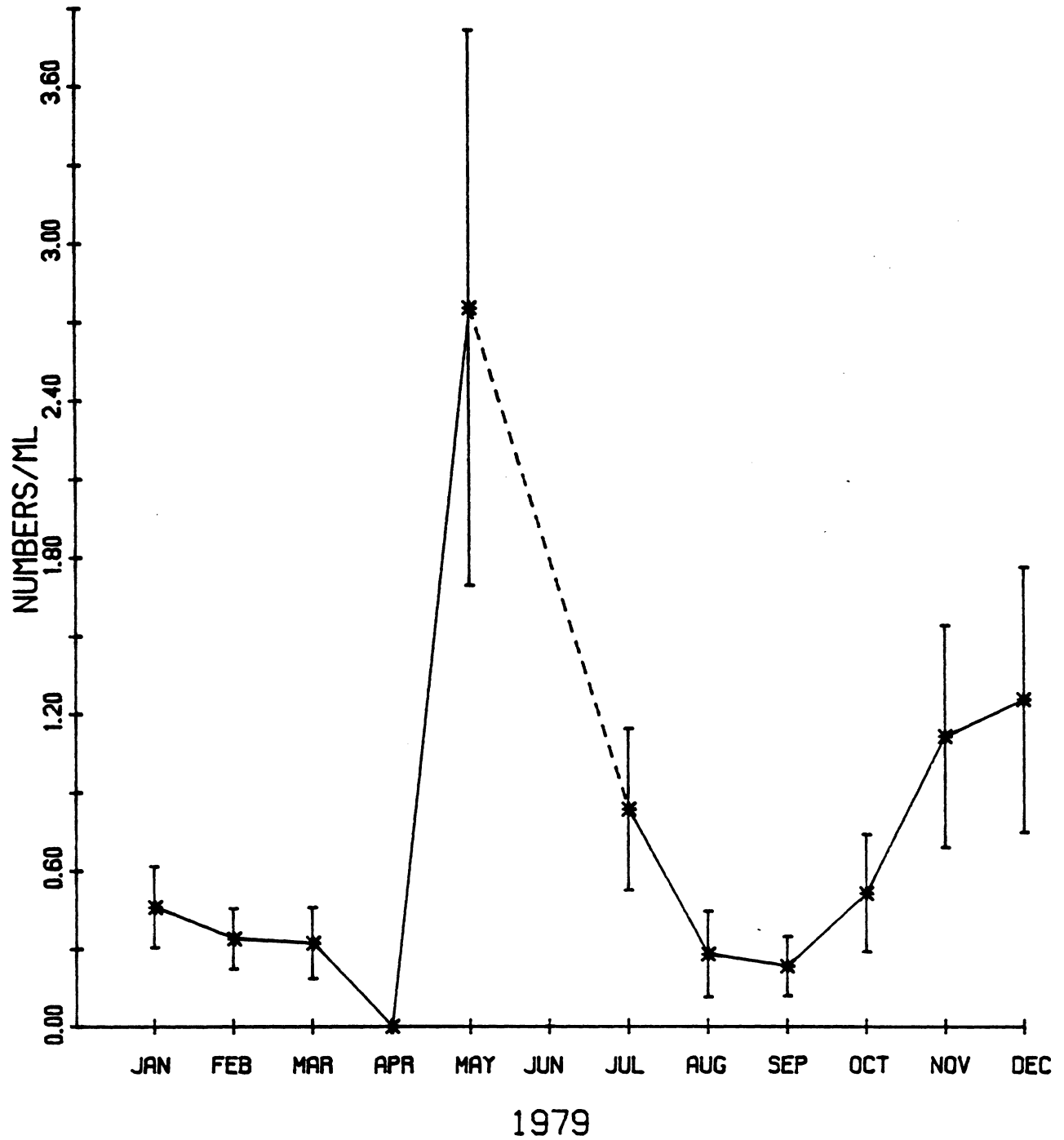


FIG. 9. Variation of desmid numbers during 1979.

TABLE 11. Monthly variation of other algae from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	62.4(18.1)			50.8(11.2)	84.4(9.24)
February	7.03(3.2)	58.3(30.4)		55.6(7.19)	94.4(9.40)
March	29.4(4.4)	39.9(5.93)	16.7(5.49)	66.2(7.79)	92.0(13.8)
April	70.0(16.9)	91.1(42.8)	167.(20.8)	57.6(10.9)	29.8(6.57)
May	84.9(17.2)	148.(27.8)	55.6(10.5)	104.(11.3)	111.(30.5)
June	148.(29.0)	104.(12.1)	37.9(7.65)	401.(44.2)	
July	480.(57.1)	361.(52.3)	193.(22.0)	514.(63.8)	40.8(6.97)
August	55.0(22.1)	192.(19.8)	206.(26.7)	119.(22.3)	114.(11.7)
September	31.6(6.2)	481.(54.7)	62.0(7.15)	86.6(10.3)	91.0(10.6)
October	44.0(5.0)	166.(23.7)	183.(21.4)	245.(23.7)	179.(18.4)
November	65.7(13.0)	84.7(14.5)	119.(15.6)	112.(18.5)	93.3(9.22)
December	<u>71.0(13.1)</u>	<u>42.0(7.67)</u>	<u>63.4(15.1)</u>	<u>124.(13.0)</u>	<u>96.9(10.5)</u>
Yearly Mean	98.7(39.7)	153.(39.5)	110.(22.6)	161.(20.3)	93.3(11.7)

* Mean is followed by the standard error.

OTHER ALGAE

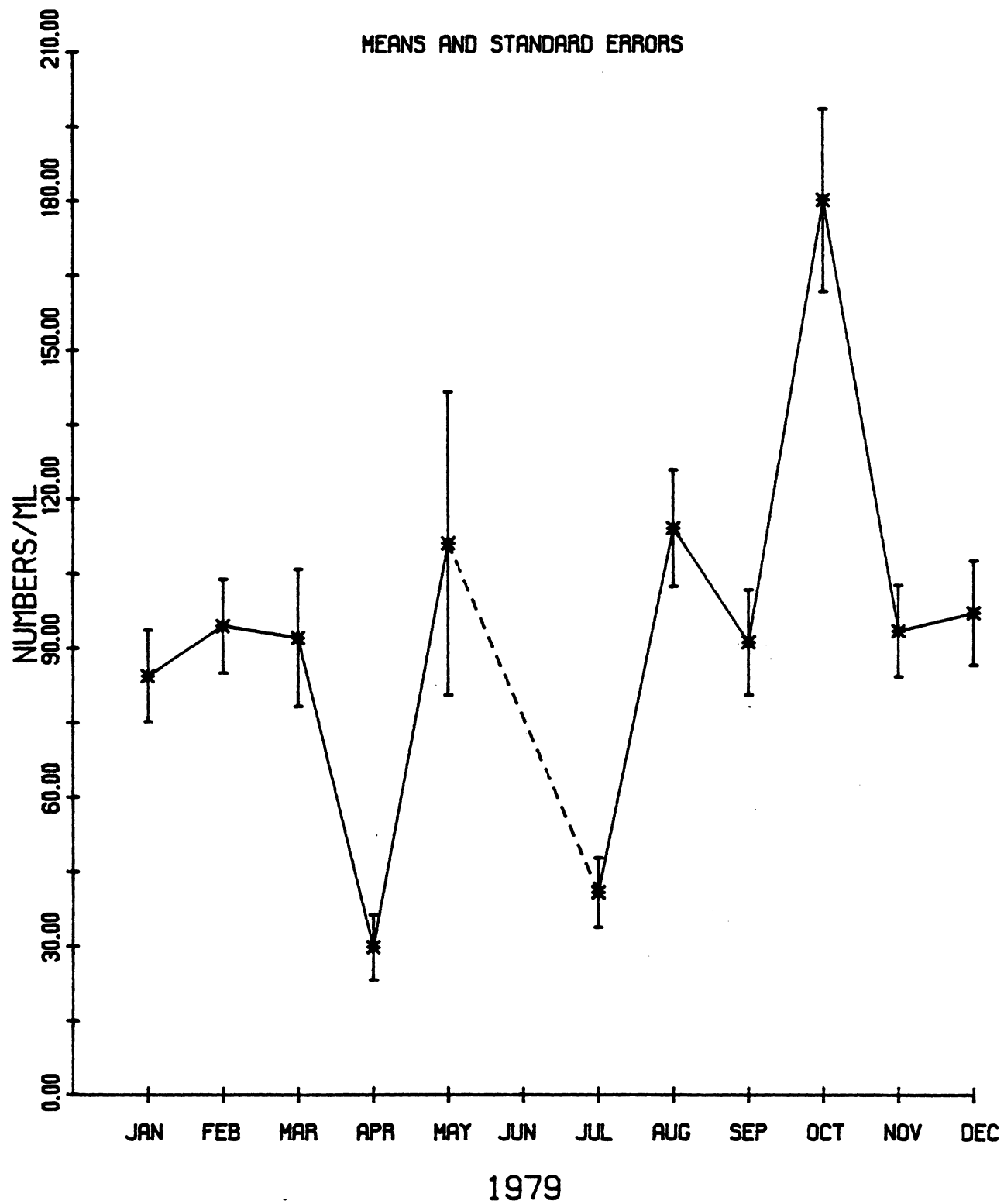


FIG. 10. Variation of other algae numbers during 1979.

TABLE 12. Monthly variation of total algae from 1975 through 1979 (cells/mL).

Month	1975*	1976*	1977*	1978*	1979*
January	3,530.(429.)			1,486.(210.)	1,094.(92.6)
February	2,970.(318.)	1,410.(147.)		465.(81.8)	691.(62.8)
March	3,340.(421.)	1,840.(182.)	2,500.(206.)	681.(63.9)	1,330.(121.)
April	5,020.(816.)	2,990.(200.)	3,890.(336.)	1,503.(170.)	3,850.(242.)
May	5,800.(413.)	4,520.(396.)	1,860.(214.)	4,843.(396.)	3,972.(224.)
June	3,710.(302.)	1,550.(132.)	1,650.(249.)	7,223.(461.)	
July	4,200.(243.)	7,940.(836.)	2,280.(156.)	3,884.(321.)	1,187.(92.3)
August	1,270.(92.8)	3,140.(292.)	2,170.(296.)	1,456.(172.)	1,256.(82.0)
September	2,380.(208.)	5,050.(675.)	1,690.(140.)	1,351.(113.)	1,729.(198.)
October	2,490.(286.)	2,720.(291.)	2,680.(285.)	4,533.(450.)	2,783.(157.)
November	2,150.(259.)	3,090.(237.)	3,210.(428.)	3,576.(407.)	2,547.(6.18)
December	<u>2,790.(170.)</u>	<u>2,870.(312.)</u>	<u>1,840.(189.)</u>	<u>5,058.(414.)</u>	<u>4,146.(308.)</u>
Yearly Mean	3,280.(399.)	3,390.(519.)	2,380.(228.)	3,005.(272.)	2,235.(387.)

* Mean is followed by the standard error.

TOTAL ALGAE

MEANS AND STANDARD ERRORS

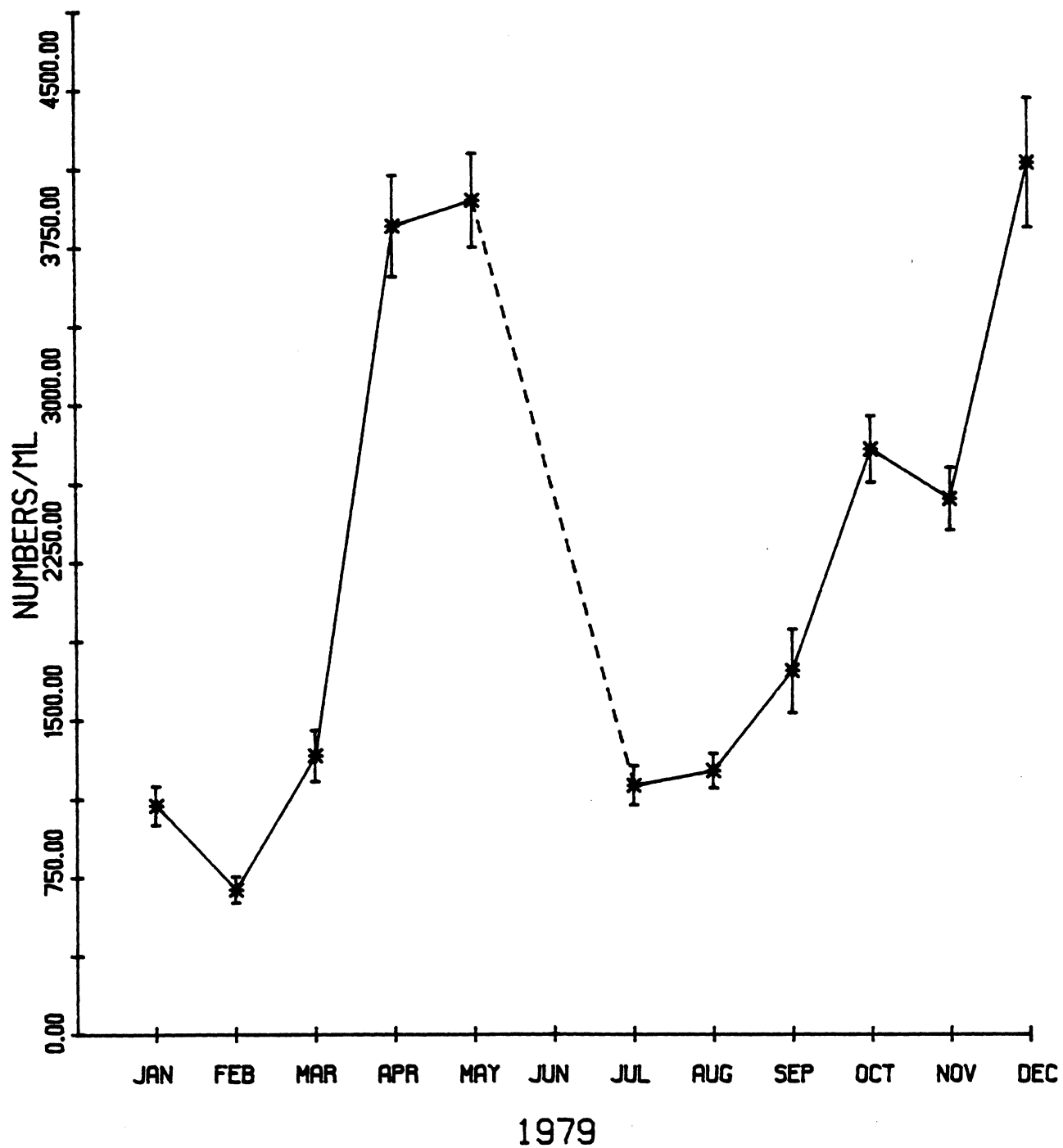


FIG. 11. Variation of total algae numbers during 1979.

conditions resumed. The 1979 mean abundance was lowest in the five plant operational years. The reason for this low count may be the absence of data for June, when population is usually high compared to the rest of the year.

Monthly Variations of Phytoplankton Community Structure

Occurrences of Dominant and Co-dominant forms --

For this report, any form constituting 10% or more of the total population in a sample was considered dominant. A comparison of these monthly frequencies for the years in which the plant has been in operation can reveal any change which has occurred in the distribution of these species during the period. Those forms which appeared relatively infrequently (less than 50% of the total monthly samples) as dominant forms were excluded from consideration. If they were included, the resulting complexity could obscure the existing patterns. The monthly comparisons among the years were made for March to December, when complete data from 1975 to 1979 were available.

In March, Tabellaria fenestrata v. intermedia and centric diatoms were dominant in 1975; Cyclotella stelligeria and flagellates were dominant in 1976; flagellates, Fragillaria crotonensis, and Synedra filiformis were dominant in 1977; Stephanodiscus sp. were dominant in 1978 (Table 13); and flagellates were dominant in 1979. During April, the dominant forms were flagellates and Cyclotella stelligera in 1975; Fragilaria crotonensis and Asterionella formosa in 1976; flagellates, Fragilaria crotonensis, chrysophycean flagellates, and Synedra filiformis in 1977; chrysophycean flagellates and Stephanodiscus sp. in 1978; and Stephanodiscus minutus in 1979 (Table 14). The dominant forms for May were Tabellaria fenestrata v. intermedia in 1975, flagellates in 1976, flagellates in 1977, Melosira granulata in 1978, and flagellates and

TABLE 13. Occurrence of dominant forms in March 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Anacystis incerta</u>	0	5	0	2	7
<u>Cyclotella stelligera</u>	4	6	0	0	0
Flagellates	1	9	9	3	18
<u>Gomphosphaeria lacustris</u>	2	3	2	0	3
<u>Cyclotella</u> sp.	0	3	0	0	0
<u>Asterionella formosa</u>	0	1	0	0	0
Blue-green, unknown cells	0	1	0	0	0
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	9	0	0	0	0
Centric diatoms, unknown	6	0	0	4	0
<u>Stephanodiscus</u> sp.	3	0	0	11	0
<u>Fragilaria crotonensis</u>	1	0	11	0	1
Chrysophycean flagellate sp.	0	0	2	0	6
<u>Synedra filiformis</u>	0	0	11	0	0
<u>Stephanodiscus</u> #5	0	0	0	5	0
<u>Stephanodiscus minutus</u>	0	0	0	0	3
Number of samples	9	12	12	12	18

TABLE 14. Occurrence of dominant forms in April 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Cyclotella stelligera</u>	5	1	0	0	0
Flagellates	6	0	6	5	1
<u>Fragilaria crotonensis</u>	1	6	9	0	0
<u>Gomphosphaeria lacustris</u>	1	0	0	0	0
<u>Stephanodiscus minutus</u>	1	0	0	0	12
<u>Stephanodiscus tenuis</u>	2	0	0	0	0
<u>Stephanodiscus</u> #5	0	0	0	3	0
<u>Stephanodiscus</u> sp.	0	0	0	10	4
<u>Anacystis incerta</u>	1	3	1	3	0
<u>Asterionella formosa</u>	0	12	0	0	5
<u>Rhizosolenia gracilis</u>	0	3	0	0	0
Green colony, unknown	0	1	0	0	0
<u>Fragilaria intermedia</u> v. <u>fallax</u>	0	1	0	0	0
Chrysophycean flagellate sp.	0	0	6	9	0
<u>Synedra filiformis</u>	0	0	11	0	0
<u>Synedra ostenfeldii</u>	0	0	1	0	0
Number of samples	9	12	12	12	12

Asterionella formosa in 1979 (Table 15). In June, the dominant forms were flagellates and Tabellaria fenestrata v. intermedia in 1975, flagellates and Dinobryon divergens in 1976, Fragilaria crotonensis in 1977, and chrysophycean flagellates in 1978 (Table 16). As no sample was collected in June, 1979, there was no information on dominant forms available for this month. In July, Cyclotella stelligera, Dictyosphaerium pullchelum, and Gloeocystis sp. were dominant in 1975; no forms were dominant in more than 50% of the total samples in 1976; Cyclotella sp., Cyclotella comensis, and Fragilaria crotonensis were dominant in 1977; Fragilaria crotonensis and Scenedesmus bicellularis were dominant in 1978; and flagellates, Fragilaria crotonensis, Chrysophycean flagellate spp., and Anabaena flos-aquae were dominant in 1979 (Table 17). In August, Anacystis incerta and Chromulina parvula were dominant in 1975, Fragilaria crotonensis was dominant in 1976, Anacystis incerta and flagellates were dominant in 1977, Fragilaria crotonensis was dominant in 1978, and Fragilaria crotonensis and Anacystis incerta were dominant in 1979 (Table 18). In September, Anacystis incerta and flagellates predominated in 1975; Fragilaria crotonensis did so in 1976; Anacystis incerta and flagellates did so in 1977; Anacystis incerta did so in 1978; and Anacystis incerta, flagellates, and Melosira granulata did so in 1979 (Table 19). In October, Anacystis incerta, flagellates, and Gomphosphaeria lacustris were dominant in 1975; flagellates were dominant in 1976; Anacystis incerta, Fragilaria crotonensis, and flagellates were dominant in 1977; Anacystis incerta, Gomphosphaeria lacustris, and Melosira granulata were dominant in 1978; and Anacystis incerta and Gomphosphaeria lacustris were dominant in 1979 (Table 20). During November, the dominant forms were flagellates, Anacystis incerta, Fragilaria crotonensis, and Cyclotella comensis in 1975; flagellates and Cyclotella sp. in 1976;

TABLE 15. Occurrence of dominant forms in May 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Anacystis incerta</u>	4	0	0	0	1
<u>Fragilaria crotonensis</u>	4	0	2	4	1
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	5	0	1	0	0
Flagellates	4	11	9	1	9
<u>Ochromonas</u> sp.	0	5	0	0	0
Centric diatom, unknown	0	1	0	0	0
<u>Oscillatoria limnetica</u>	0	1	0	0	0
<u>Rhizosolenia gracilis</u>	0	1	0	0	0
<u>Cyclotella</u> sp.	0	1	0	0	0
<u>Asterionella formosa</u>	0	1	0	3	12
<u>Stephanodiscus subtilis</u>	0	1	0	0	0
<u>Stephanodiscus</u> sp.	0	0	0	1	0
<u>Gomphosphaeria lacustris</u>	0	0	1	0	0
Chrysophycean flagellate sp.	0	0	5	1	0
<u>Synura</u> sp.	0	0	1	0	0
<u>Melosira granulata</u>	0	0	0	6	0
<u>Synedra ostenfeldii</u>	0	0	0	0	8
Number of samples	9	12	12	12	12

TABLE 16. Occurrence of dominant forms in June 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
Flagellates	9	11	2	0	-
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	10	0	5	0	-
<u>Fragilaria capucina</u>	1	0	0	0	-
<u>Stephanodiscus tenuis</u>	2	0	0	0	-
<u>Oscillatoria limnetica</u>	2	0	0	0	-
<u>Anacystis incerta</u>	1	0	1	2	-
<u>Gomphosphaeria lacustris</u>	2	1	1	2	-
<u>Fragilaria crotonensis</u>	2	0	8	1	-
<u>Chlorella</u> sp.	0	1	0	0	-
<u>Diatoma tenue</u> var. <u>elongatum</u>	0	1	0	0	-
<u>Dinobryon bavaricum</u>	0	5	0	0	-
<u>Dinobryon divergens</u>	0	9	0	0	-
Chrysophycean flagellate sp.	0	0	2	12	-
<u>Merismopedia elegans</u>	0	0	1	0	-
<u>Cyclotella stelligera</u>	0	0	1	0	-
Number of samples	12	12	12	12	-

TABLE 17. Occurrence of dominant forms in July 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Anabaena flos-aquae</u>	0	0	0	0	8
<u>Anacystis incerta</u>	2	0	0	3	2
<u>Cyclotella</u> sp.	2	0	8	0	0
<u>Cyclotella stelligera</u>	9	0	0	0	0
Chrysophycean flagellate sp.	0	0	0	0	11
<u>Dictyosphaerium pulchellum</u>	10	0	0	0	0
<u>Gloeocystis</u> sp.	9	1	0	0	0
<u>Merismopedia tenuissima</u>	1	0	0	0	0
<u>Gomphosphaeria lacustris</u>	1	0	1	2	4
Flagellates	4	0	3	5	10
Green coccoid, unknown	1	0	0	0	0
<u>Gloeocystis planctonica</u>	1	0	0	1	0
<u>Stephanodiscus</u> sp.	0	1	0	0	0
Centric diatom, unknown	0	5	0	0	0
<u>Melosira granulata</u>	0	0	0	1	0
<u>Fragilaria crotonensis</u>	0	5	10	11	6
<u>Sphaerocystis</u> sp.	0	1	0	0	0
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	0	0	0	2	0
<u>Stephanodiscus subtilis</u>	0	1	0	0	0
<u>Cyclotella comensis</u>	0	0	12	0	0
<u>Scenedesmus bicellularis</u>	0	0	0	6	0
Number of samples	12	12	12	18	12

TABLE 18. Occurrence of dominant forms in August 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Anacystis incerta</u>	8	3	10	3	15
<u>Anacystis cyanea</u>	0	0	0	1	1
<u>Anacystis thermalis</u>	0	0	5	0	0
<u>Anabaena flos-aquae</u>	0	0	0	6	0
<u>Agmenellum quadruplicatum</u>	0	0	0	0	1
<u>Chromulina parvula</u>	9	0	0	0	0
<u>Gomphosphaeria lacustris</u>	3	2	0	3	5
<u>Cyclotella stelligera</u>	4	0	0	0	0
<u>Gloeocystis</u> sp.	5	4	0	0	0
Flagellates	3	5	6	4	8
<u>Synura</u> sp.	1	0	0	0	0
<u>Fragilaria crotonensis</u>	0	11	0	18	14
<u>Gloeocystis planctonica</u>	0	1	0	1	0
Chrysophycean flagellate sp.	0	1	5	0	1
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	0	0	0	1	0
<u>Crucigenia rectangularis</u>	0	0	4	0	0
Dinobryon divergens	0	0	0	0	1
<u>Cyclotella</u> sp.	0	0	1	0	0
Green cells, undetermined	0	0	0	0	1
Green colony, unknown	0	0	0	0	3
Number of samples	12	12	12	18	18

TABLE 19. Occurrence of dominant forms in September 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Anabaena flos-aquae</u>	0	0	0	0	1
<u>Anacystis incerta</u>	11	4	12	18	16
<u>Fragilaria crotonensis</u>	2	8	0	0	0
<u>Gomphosphaeria lacustris</u>	5	0	2	1	4
Flagellates	6	1	6	1	9
<u>Anacystis thermalis</u>	4	0	0	0	1
<u>Melosira granulata</u>	0	0	0	8	8
<u>Ochromonas</u> sp.	2	0	0	0	0
<u>Gloeocystis</u> sp.	0	5	0	0	0
<u>Botryococcus braunii</u>	0	0	0	1	0
<u>Sphaerocystis</u> sp.	0	1	0	0	0
<u>Gloeocystis planctonica</u>	0	0	0	1	0
Chrysophycean flagellate sp.	0	1	0	0	1
<u>Anacystis cyanea</u>	0	0	0	1	0
Number of samples	12	12	12	18	16

TABLE 20. Occurrence of dominant forms in October 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Agmenellum quadruplicatum</u>	0	0	0	0	1
<u>Anacystis incerta</u>	10	5	10	16	15
<u>Fragilaria crotonensis</u>	1	2	10	0	0
Flagellates	8	9	8	0	0
<u>Gomposphaeria lacustris</u>	6	2	3	13	9
<u>Ochromonas</u> sp.	3	0	0	0	0
<u>Gomposphaeria</u> sp.	0	0	0	1	0
<u>Cyclotella comensis</u>	0	2	0	0	0
<u>Gloeocystis planctonica</u>	0	1	0	0	0
<u>Melosira granulata</u>	0	0	0	13	5
Chrysophycean flagellate sp.	0	2	0	0	0
<u>Gloeocystis</u> sp.	0	1	1	0	0
<u>Anacystis cyanea</u>	0	0	1	0	0
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	0	0	1	0	0
Number of samples	10	12	12	18	18

flagellates, Anacystis incerta, and Gomphosphaeria lacustris in 1977; Anacystis incerta, Fragilaria crotonensis, and Gomphosphaeria lacustris in 1978, and flagellates, Anacystis incerta, and Gomphosphaeria lacustris in 1979 (Table 21). In the month of December, centric diatoms and Cyclotella stelligera were dominant in 1975; Fragilaria crotonensis and flagellates were dominant in 1976; Anacystis incerta, Gomphosphaeria lacustris, and Tabellaria fenestrata v. intermedia were dominant in 1977; Gomphosphaeria lacustris and Anacystis incerta were dominant in 1978, and Anacystis incerta and Fragilaria crotonensis were dominant in 1979 (Table 22).

No consistent trend of change in dominant species was observed in the monthly comparisons during the years 1975 through 1979. However, if the data are tabulated for those diatoms which are associated with an identifiable trophic level (Table 23), certain patterns of total annual occurrence for the dominant diatom species emerge (Table 24). These patterns are summarized in Table 25. The occurrences of mesotrophic species not tolerant of nutrient enrichment continuously decrease from 34 in 1975 to 0 in 1979. On the other hand, there has been an increase from 47 in 1975 to 62 in 1979 in the occurrences of mesotrophic species which are tolerant of moderate nutrient enrichment. The highest numbers of occurrences were in 1976 and 1977. The highest number of occurrences of eutrophic species was in 1979. A combination of decreasing occurrences of mesotrophic species that are intolerant of nutrient enrichment and of higher occurrences of eutrophic and mesotrophic species tolerant of moderate nutrient enrichment illustrates the continuing degradation of this region of Lake Michigan.

Between 1975 and 1979, important trends have been observed in entrainment assemblages (Table 26): 1) a doubling in the occurrence of the blue-green algae

TABLE 21. Occurrence of dominant forms in November 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
Flagellates	7	8	9	0	11
<u>Anacystis incerta</u>	7	5	10	11	10
Chrysophycean flagellate sp.	0	3	3	0	0
<u>Fragilaria crotonensis</u>	6	4	4	7	6
<u>Agmenellum quadruplicatum</u>	1	0	1	1	1
<u>Gomphosphaeria lacustris</u>	4	0	8	9	5
Centric diatom, unknown	2	0	0	0	0
<u>Stephanodiscus</u> sp.	1	0	0	0	0
<u>Cyclotella comensis</u>	10	0	0	0	0
<u>Cyclotella</u> sp.	0	7	0	0	0
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	0	1	0	0	0
<u>Asterionella formosa</u>	0	2	2	0	0
<u>Gloeocystis</u> sp.	0	1	0	0	0
<u>Anacystis thermalis</u>	0	0	0	0	2
Number of samples	12	12	12	12	12

TABLE 22. Occurrence of dominant forms in December 1975, 1976, 1977, 1978, and 1979.

Form	Occurrences				
	1975	1976	1977	1978	1979
<u>Asterionella formosa</u>	0	0	0	0	5
Centric diatom, unknown	9	0	0	0	0
<u>Cyclotella stelligera</u>	9	0	0	0	0
<u>Ochromonas</u> sp.	3	0	0	0	0
<u>Sphaerocystis schroeteri</u>	1	0	0	0	0
<u>Gomphosphaeria lacustris</u>	1	1	7	17	5
<u>Stephanodiscus minutus</u>	1	0	0	0	0
<u>Stephanodiscus</u> sp.	1	0	0	0	0
<u>Cyclotella comensis</u>	1	1	0	0	0
<u>Cyclotella</u> sp.	1	0	0	0	0
<u>Anacystis incerta</u>	1	3	12	16	6
<u>Fragilaria crotonensis</u>	0	12	0	0	11
Flagellates	0	6	0	2	1
<u>Fragilaria capucina</u> var. <u>lanceolata</u>	0	1	0	0	0
<u>Anabaena flos-aquae</u>	0	1	1	0	0
<u>Gloeocystis planctonica</u>	0	2	0	0	0
<u>Tabellaria fenestrata</u> var. <u>intermedia</u>	0	0	6	0	0
<u>Agmenellum quadruplicatum</u>	0	0	1	1	0
<u>Anacystis thermalis</u>	0	0	2	0	0
Number of samples	11	12	12	18	12

TABLE 23. Apparent trophic preference and abundance of selected diatoms in Lake Michigan.¹

Selected Diatoms	Trophic Preference				
	O	M1	M2	E	EI
<u>Cyclotella comta</u> (Ehr.) Kütz.	P	M	P		
<u>Cyclotella operculata</u> (Ag.) Kütz.	M				
<u>Cyclotella ocellata</u> Pant.	M	P			
<u>Cyclotella kuetzingiana</u> Thwaites	P	M	P		
<u>Cyclotella stelligeria</u> Cl. n. Grun.	P	M	P		
<u>Melosira distans</u> (Ehr.) Kütz.	M				
<u>Melosira distans</u> var. <u>alipigena</u> Grun.					M
<u>Melosira islandica</u> O. Mull.	P	M	P		
<u>Tabellaria fenestrata</u> (Lyngb.) Kütz.		P	M	P	
<u>Tabellaria flocculosa</u> (Roth) Kütz.		M	P		
<u>Rhizosolenia eriensis</u> H. L. Smith	P	M	P		
<u>Stephanodiscus transilvanicus</u> Pant.	P	M			
<u>Synedra ulna</u> var. <u>chaseana</u> Thomas	P	M			
<u>Cyclotella michiganiana</u> Skv.	P	M	P		
<u>Asterionella formosa</u> Hass.		P	M	P	
<u>Fragilaria crotonensis</u> Kitton		P	M	P	
<u>Stephanodiscus alpinus</u> Hust. ex Huber-Pestalozzi		P	M	P	
<u>Stephanodiscus minutus</u> Grun. ex Cleve and Moll.				P	M
<u>Stephanodiscus niagarae</u> Ehr.			P	M	
<u>Stephanodiscus hantzschii</u> Grun.			P	M	

(continued)

Symbols: O, oligotrophic; M1, mesotrophic but intolerant of nutrient enrichment; M2, mesotrophic and tolerant of moderate nutrient enrichment; E, eutrophic; EI, recently introduced eutrophic species; P, presence of species; and M, apparent maximum abundance of the species.

References: Holland (1968, 1969); Stoermer and Yang (1969, 1970); Holland and Beeton (1972). (Courtesy to Tarapchak and Stoermer).

¹Tarapchak and Stoermer (1976)

TABLE 23. (concluded).

Selected Diatoms	Trophic Preference				
	0	M1	M2	E	EI
<u>Synedra delicatissima</u> Lewis	P		M	P	
<u>Synedra ulna</u> v. <u>danica</u> (Kütz.) Grun.	P		M	P	
<u>Synedra ostenfeldii</u> (Krieger) A. Cleve	P		M	P	
<u>Synedra filiformis</u> Grun.	P		M	P	
<u>Amphipleura pellucida</u> (Kütz.)			P	M	P
<u>Melosira granulata</u> (Ehr.) Ralfs			P	M	
<u>Melosira granulata</u> var. <u>angustissima</u> Mull.			P	M	
<u>Fragilaria capucina</u> Desm.			P	M	
<u>Fragilaria capucina</u> var. <u>mesolepta</u> (Rabh.) Grunow			P	M	
<u>Fragilaria construens</u> (Ehr.) Grunow			P	M	
<u>Fragilaria intermedia</u> Grun.			P	M	
<u>Stephanodiscus tenuis</u> Hust.				P	M
<u>Asterionella bleakeleyi</u> Wm. Smith				P	M
<u>Diatoma tenue</u> v. <u>elongatum</u> Lyng.				P	M
<u>Stephanodiscus binderanus</u> (Kütz.) Krieger				P	M
<u>Stephanodiscus subtilis</u> (Van Goor) A. Cleve				P	M
<u>Nitzschia dissipata</u> (Kütz.) Grun.				M	P
<u>Coscinodiscus subsalsa</u> Juhl.-Dannf.					M

TABLE 24. The annual occurrence of selected dominant diatom forms in 1975, 1976, 1977, 1978, and 1979. (Refer to Table 23 for definition of symbols M1, M2, and E).

	1975	1976	1977	1978	1979
<u>Stephanodiscus minutus</u> (E)	2	8	0	0	17
<u>Fragilaria capucina</u> (E)	2	1	0	0	0
<u>Stephanodiscus tenuis</u> (E)	4	1	0	0	
<u>Stephanodiscus subtilis</u> (E)	0	2	0	0	0
<u>Diatoma tenue</u> v. <u>elongatum</u> (E)	0	1	0	0	0
<u>Fragilaria crotonensis</u> (M2)	17	52	54	48	40
<u>Tabellaria fenestrata</u> var. <u>intermedia</u> (M2)	30	1	16	6	0
<u>Synedra filiformis</u> (M2)	0	0	20	0	0
<u>Asterionella formosa</u> (M2)	0	17	2	3	22
<u>Cyclotella stelligera</u> (M1)	34	11	1	0	0
<u>Cyclotella</u> sp.	3	12	9	0	0
<u>Cyclotella comensis</u>		13	12	0	0
<u>Melosira granulata</u> (E)	0	0	0	28	13

TABLE 25. The annual occurrence of dominant diatom forms with respect to each trophic level for 1975, 1976, 1977, 1978, and 1979. (Refer to Table 23 for definition of symbols M1, M2, and E).

	1975	1976	1977	1978	1979
Mesotrophic, intolerant of nutrient enrichment	34	11	1	0	0
Mesotrophic, tolerant of moderate nutrient enrichment	47	70	92	57	62
Eutrophic	8	13	0	28	30

TABLE 26. The annual occurrence of dominant blue-green algae and flagellates in 1975, 1976, 1977, 1978, and 1979.

	1975	1976	1977	1978	1979
Flagellates	43	71	57	32	95
Chrysophycean flagellate (sp.)	1	4	24	23	27
<u>Anacystis incerta</u>	42	33	57	83	85
<u>Gomphosphaeria lacustris</u>	24	13	24	49	48
Dominant blue-green	66	46	81	132	133

Anacystis incerta, Gomphosphaeria lacustris, and flagellates; 2) a large increase in the number of occurrences of chrysophycean flagellates, and 3) the continued increase in occurrence of dominant blue-green algae. The mechanisms which cause these changes are presently unknown and, from the information available, it is difficult to offer a good explanation. Nevertheless, further study of these species may yield considerable insight into the factors influencing these changes.

Numbers of Forms, Diversity, and Redundancy --

When working with complex and variable assemblages of phytoplankton such as those appearing in entrainment samples from the nearshore of Lake Michigan, it is advantageous to use some quantitative measure of the distribution of populations within the various assemblages. Such measures can furnish information for assessing changes in community structure. The quantitative measures employed in this study are the number of species, diversity index, and redundancy.

The diversity index is calculated using the formula presented by Wilhm and Dorris (1968):

$$\bar{d} = - \sum_{i=1}^S (n_i/n) \log_2 (n_i/n)$$

where S is the number of species, n is the total number of phytoplankton in cells/mL, and n_i is the number of phytoplankton of the i th species. As not all forms encountered can be identified to the species level, the diversity index presented may differ somewhat from the true diversity measure.

Redundancy is a measure of the dominance of one or a few species within a population assemblage. As presented by Wilhm and Dorris (1968), it is:

$$r = \frac{\bar{d}_{\max} - \bar{d}}{\bar{d}_{\max} - \bar{d}_{\min}}$$

where \bar{d} is the diversity of a community as calculated above, \bar{d}_{\max} is the maximum diversity for the community, and \bar{d}_{\min} is the minimum diversity for the community. \bar{d}_{\max} and \bar{d}_{\min} are computed as follows:

$$\bar{d}_{\max} = (1/n)(\log_2 n! - S \log_2 [n/S]!)$$

$$\bar{d}_{\min} = (1/n)(\log_2 n! - S \log_2 [n-(S-1)]!)$$

The possible values of r vary between 0 and 1. When an r equals 0, it indicates that all the species encountered in a community have the same abundance, whereas when an r equals 1, it implies that one species dominates a community. As shown in the formula, this value is derived from the measure of species number, abundance, and diversity.

The number of forms in the 1979 entrainment samples showed a bimodal variation. In general, the primary peak of the number of forms occurs in June or July but, in the absence of the June sample (which was not collected due to plant retooling), the primary peak was October and the secondary peak in March (Table 27 and Figure 12). The number of forms varies from 32 to 67; the minimum and maximum number of forms correspond with the months of July and October, respectively. The largest changes occurred between July and August and between August and September.

TABLE 27. Comparison of the number of forms of phytoplankton for 1975, 1976, 1977, 1978, 1979, and 1979. Standard errors are included in parentheses.

Month	1975			1976			1977			1978			1979		
	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	Forms
January	--1	--1	11	59.4(2.79)	--1	--1	--1	--1	11	62.9(2.47)	18	59.7(3.03)			
February	--1	51.1(1.90)	12	57.3(1.64)	--1	--1	--1	--1	12	48.9(1.01)	18	46.6(1.37)			
March	9	51.7(1.89)	12	59.3(1.59)	12	52.9(2.36)	12	52.9(2.36)	12	40.3(1.16)	18	56.7(1.80)			
April	9	48.3(1.38)	12	56.1(1.43)	12	55.5(3.37)	12	55.5(3.37)	12	55.1(3.24)	12	44.7(1.97)			
May	9	47.4(1.78)	12	60.3(2.84)	12	46.4(2.91)	12	46.4(2.91)	12	81.9(2.07)	12	38.8(1.39)			
June	12	49.2(1.77)	12	65.8(1.77)	12	64.1(3.59)	12	64.1(3.59)	12	85.3(4.17)	--1	--1			
July	12	51.6(.892)	12	87.3(3.78)	12	57.7(2.64)	12	57.7(2.64)	18	68.7(2.73)	12	32.0(1.35)			
August	12	44.5(2.32)	12	53.4(3.31)	12	46.9(2.26)	12	46.9(2.26)	18	49.9(1.73)	18	48.3(1.88)			
September	10	44.1(3.12)	12	84.8(4.30)	12	60.3(2.75)	12	60.3(2.75)	18	67.1(2.53)	16	64.6(3.75)			
October	12	54.0(2.18)	12	58.8(2.77)	12	52.3(2.60)	12	52.3(2.60)	18	78.2(3.02)	18	67.2(1.92)			
November	12	50.3(2.11)	12	57.2(1.74)	12	46.6(1.85)	12	46.6(1.85)	12	72.6(3.47)	12	56.5(1.95)			
December	11	50.8(1.74)	12	56.5(1.81)	12	56.4(2.52)	12	56.4(2.52)	13	55.1(2.19)	12	61.0(2.87)			
Yearly Mean		49.4(.969)		63.1(3.25)		53.9(1.92)		53.9(1.92)		63.9(1.92)		52.4(3.36)			

¹Samples were not collected where dashes appear.

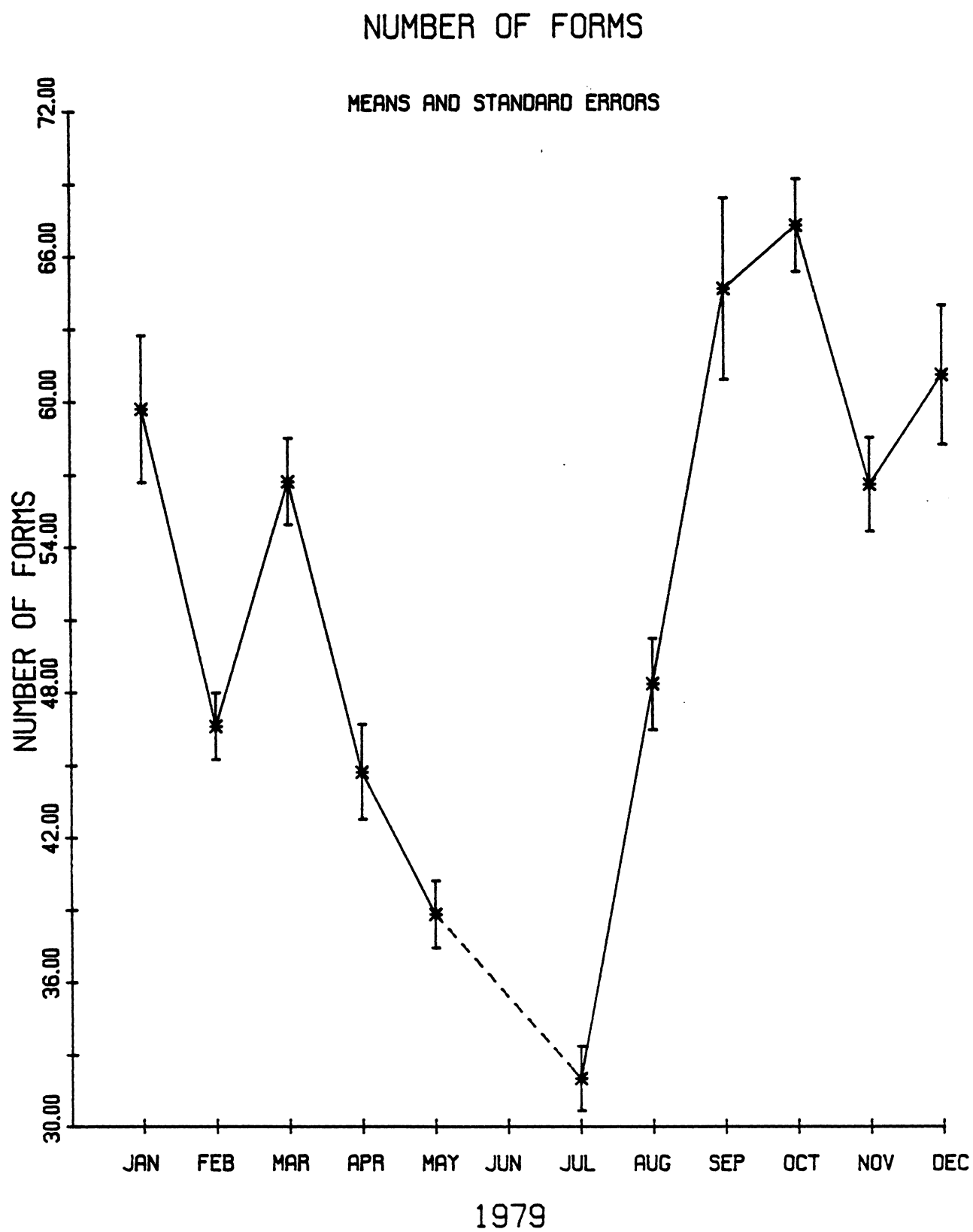


FIG. 12. Variation of number of forms during 1979.

Species number fluctuations have long been an important issue. Many theories attempt to explain this phenomenon. The one offering the simplest and most plausible explanation for this was proposed by Moss (1973) who explained that different species begin to divide at different times of the year depending on their specific requirements for light, temperature, and nutrient types and levels. Most of these species are probably present in at least very small numbers throughout the year, and from these inocula larger populations can develop. After growth of a large population, decline occurs as the number of cells returns to the inoculum level. Population size depends on the balance between growth and concomitant loss by sinking, parasitism, and grazing. After the peak population has been reached, there is a rapid initial decline. As some populations decline, others grow, and with time the complexity of overlap increases, leading to progressively greater diversity. This hypothesis seems to explain why the number of forms increased rapidly in late spring, late summer, or early autumn after an initial decline in spring and summer population. This hypothesis alone cannot fully illustrate all the changes in the system as the species fluctuation is also governed by many biotic and abiotic factors which vary from year to year. However, the increase in species numbers in summer has often been associated with upwelling which makes available hypolimnetic nutrients, including orthophosphate and silica, which stimulate the growth of some forms (Rossmann et al. 1979).

The diversity index is an estimate of the structure of communities. It measures the degree to which individuals are represented in an assemblage, and is determined by the number of species and the degree of apportionment of individuals among species. For example, a diversity index varies with (1) large numbers of species, or (2) a high degree of apportionment of individuals among

species, or (3) both of the above. In 1979, diversity reached its maximum in January and its minimum in July, corresponding with the values 4.34 and 3.24, respectively (Table 28 and Figure 13). The minimum coincided with the time when the minimum number of species occurred. This phenomenon does not always occur; frequently, the number of species does not have a strong influence on the diversity index. This is because the diversity index depends on not only the number of species but also the codominancy of many species. Therefore, it is not uncommon that a sample with a high abundance where one species is dominant has a relatively low diversity value. In fact, the cases of September 1977, October 1978, and September 1979 illustrate this situation: a large number of species was encountered, but only one species, Anacystis incerta, was the dominant phytoplankter appearing at the time. Despite these exceptions, species number has often been significantly correlated with the diversity indices (Rossmann et al. 1980). In the open lake, the diversity index normally ranges from values slightly greater than zero (in bloom situations) to values as high as 4.5 (Tarapchak and Stoermer 1976). In this system, however, the monthly mean index of the 1979 entrained samples varied from 3.24 to 4.34, with an annual mean of 3.86. According to the Margalef (1968) classification, the ranges of values corresponding to trophic states are as follows: oligotrophic, >3.5; mesotrophic, 2.5 to 3.5; and eutrophic, <2.5. Considering the annual mean of diversity, this geographic region is still far from a state in which any disturbance drastically changes algal community structure and thereby significantly reduces the diversity index.

In 1979, redundancy was low in January and March and high in September (Table 29, Figure 14). Redundancy reached maximum and minimum values in September and March, respectively. The high redundancy values in September

TABLE 28. Comparison of phytoplankton diversities for 1975, 1976, 1977, 1978, and 1979. Standard errors are included in parentheses.

Month	1975			1976			1977			1978			1979		
	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	
January	--1	--1	11	4.29(.0457)	--1	--1	--1	--1	11	4.54(.089)	18	4.34(0.102)			
February	9	4.35(.0473)	12	4.47(.0591)	--1	--1	--1	--1	12	4.38(.107)	18	4.00(0.110)			
March	9	4.30(.0544)	12	4.34(0.633)	12	3.85(.0680)	12	3.70(.110)	12	3.70(.110)	18	4.30(0.066)			
April	9	4.21(.0569)	12	4.30(.0446)	12	4.36(.0872)	12	4.24(.116)	12	4.24(.116)	12	3.82(0.078)			
May	9	3.76(.228)	12	4.37(.112)	12	2.98(.186)	12	4.98(.035)	12	4.98(.035)	12	3.48(0.074)			
June	12	4.17(.0809)	12	4.67(.0616)	12	4.62(.0836)	12	4.33(.104)	12	4.33(.104)	--	---			
July	12	3.93(.0654)	12	5.08(.0380)	12	4.00(.0564)	18	4.87(.049)	12	4.87(.049)	12	3.24(0.089)			
August	12	3.58(.163)	12	3.50(.114)	12	3.29(.161)	18	4.07(.069)	18	4.07(.069)	18	3.82(0.061)			
September	10	3.36(.189)	12	4.92(.0973)	12	3.29(.109)	18	4.40(.149)	16	4.40(.149)	16	3.55(0.084)			
October	12	3.96(.138)	12	4.48(.0823)	12	4.00(.0764)	18	3.77(.112)	18	3.77(.112)	18	4.15(0.083)			
November	12	4.02(.119)	12	3.97(.0608)	12	3.69(.0945)	12	3.58(.112)	12	3.58(.112)	12	3.81(0.046)			
December	11	<u>3.83(.0982)</u>	12	<u>3.96(.0963)</u>	12	<u>3.82(.113)</u>	18	<u>2.91(.082)</u>	12	<u>2.91(.082)</u>	12	<u>3.89(0.069)</u>			
Yearly Mean		3.95(.0924)		4.36(.124)		3.79(.159)		4.15(.095)		4.15(.095)		3.86(0.103)			

1 Samples were not collected where dashes appear.

DIVERSITY

MEANS AND STANDARD ERRORS

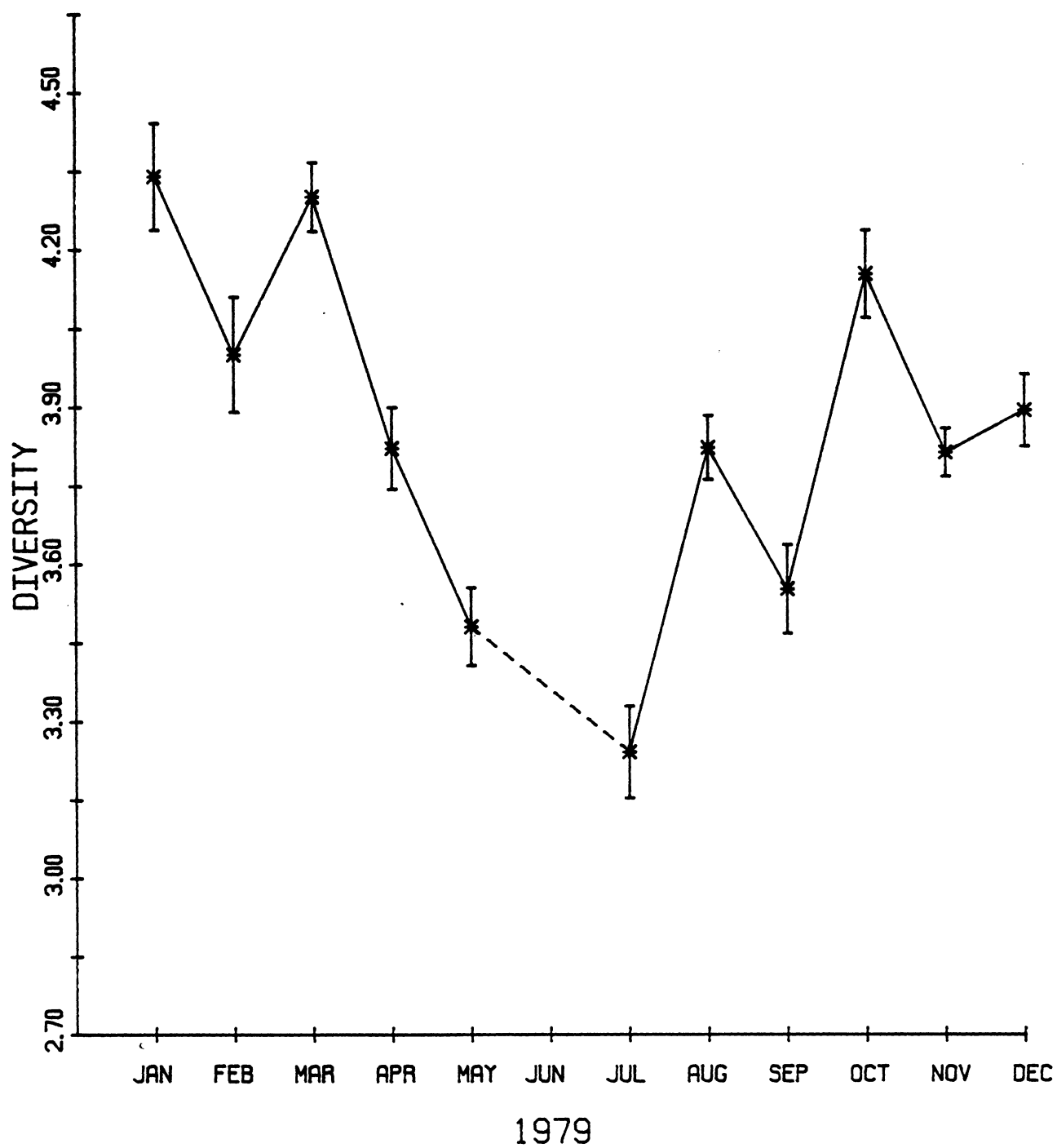


FIG. 13. Variation of diversity during 1979.

TABLE 29. Comparison of phytoplankton redundancies for 1975, 1976, 1977, 1978, and 1979. Standard errors are included in parentheses.

Month	1975			1976			1977			1978			1979		
	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	Replicates	Replicates	Forms	
January	--1	--1	11	.270(.011)	--1	--1	11	0.238(.016)	18	0.262(0.146)					
February	9	.230(.009)	12	.231(.011)	--1	--1	12	0.207(0.024)	18	0.278(0.020)					
March	9	.243(.008)	12	.263(.011)	12	.329(.008)	12	0.317(0.021)	18	0.261(0.010)					
April	9	.246(0.09)	12	.260(.007)	12	.244(.006)	12	0.272(0.013)	12	0.303(0.012)					
May	9	.327(.054)	12	.259(.015)	12	.474(.030)	12	0.217(0.007)	12	0.340(0.015)					
June	12	.258(.010)	12	.223(.010)	12	.223(.011)	12	0.329(0.013)	--	---					
July	12	.310(.011)	12	.210(.008)	12	.318(.012)	18	0.201(0.006)	12	0.358(0.014)					
August	12	.353(.026)	12	.393(.017)	12	.411(.034)	18	0.286(0.009)	18	0.318(0.014)					
September	10	.389(.029)	12	.227(.013)	12	.457(.022)	18	0.447(0.026)	16	0.422(0.012)					
October	12	.317(.021)	12	.322(.014)	12	.335(.015)	18	0.405(0.017)	18	0.317(0.016)					
November	12	.289(.019)	12	.322(.011)	12	.348(.019)	12	0.427(0.019)	12	0.348(0.011)					
December	11	<u>.325(.017)</u>	12	<u>.322(.018)</u>	12	<u>.348(.019)</u>	18	<u>0.502(0.017)</u>	12	<u>0.345(0.011)</u>					
Yearly Mean		299(.0152)		.268(.0154)		.344(.0262)		0.320(0.030)		0.323(0.014)					

1 Samples were not collected where dashes appear.

REDUNDANCY

MEANS AND STANDARD ERRORS

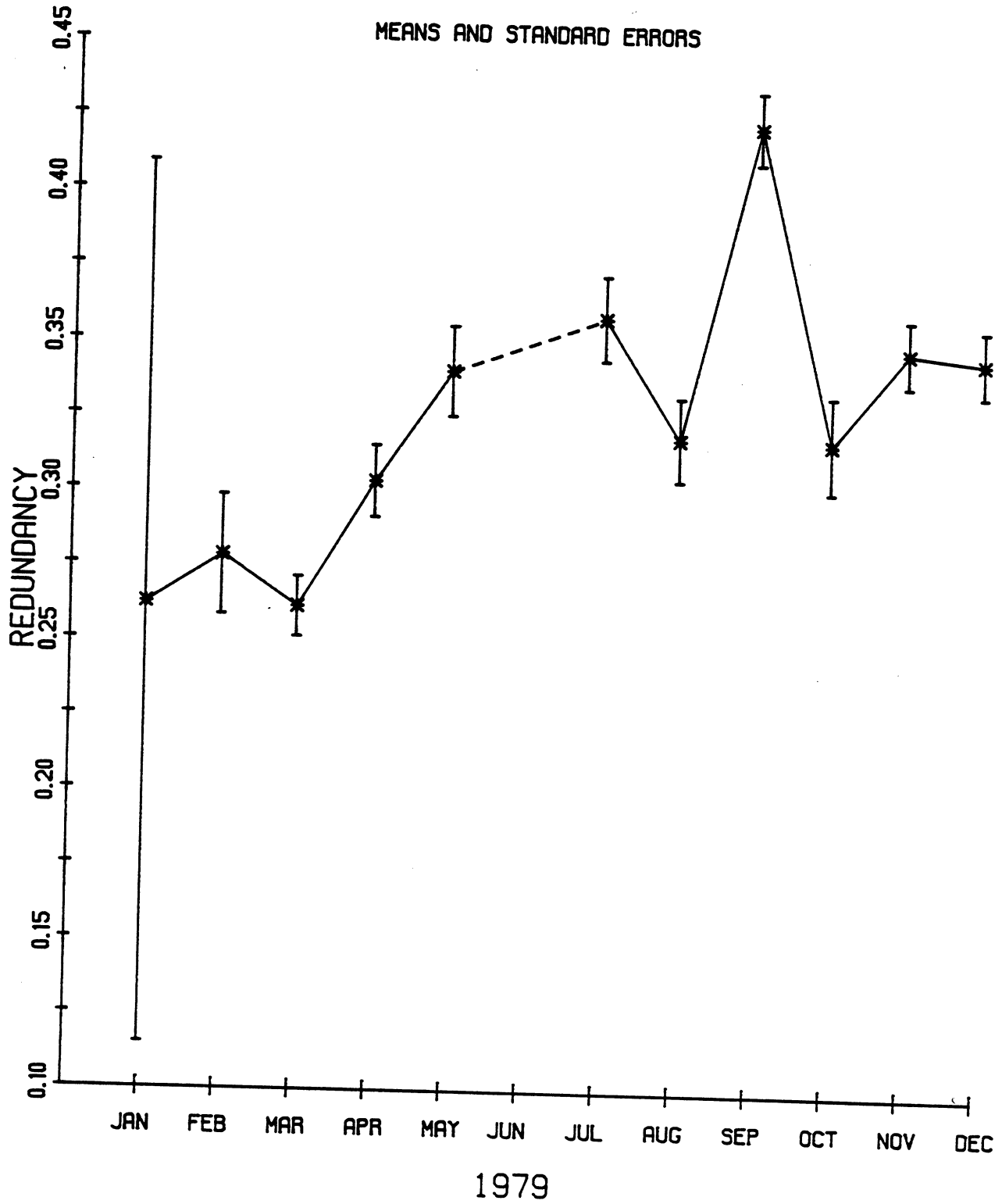


FIG. 14. Variation of redundancy during 1979.

coincided with a community of predominantly one species, Anacystic incerta, while the minimum redundancy in March reflected the codominance of a large number of species.

When the species numbers and the diversity and redundancy indices are compared annually, the number of species is high in 1976 and 1978, but low in 1975, 1977, and 1979; the diversity index is also at its peak in 1976 and 1978. The redundancy index, however, has its maximum in 1977 and its minimum in 1976.

Numbers and Biomass of Phytoplankton Passing Through the Plant --

One of the major stress factors unique to entrained phytoplankton is the artificially elevated temperature in the condenser through which entrained phytoplankton must pass. The intake water temperature during 1979 varied from 0.5°C to over 24.5°C; after the water had passed through the cooling system, its temperature at the discharge was about 10 C° higher. In the summer, the discharge water temperature approached 34°C, the temperature suggested by Patrick (1969) as having a harmful effect on algae. Because of possible harmful effects on algae, the numbers and biomass of phytoplankton passing through the condenser and the possible effect of this impact on phytoplankton were assessed.

The plant pumped water at an average rate of 2,700 m³ min⁻¹ for unit #1 and 3,500 m³ min⁻¹ for unit #2. When both units were in operation, the average rate at which water was pumped through the plant was 6,200 m³ min⁻¹. The mean monthly total phytoplankton densities were used to estimate the number of phytoplankton passing through the plant in each month. The weight of the phytoplankton was then computed using the conversion coefficient of 0.57 x 10⁻⁹gm as the average weight of a phytoplankton cell (Ayers and Seibel 1973). Using these methods, an estimate of 5.66 x 10¹⁸ phytoplankton cells or

3.20 x 10⁹gm of phytoplankton was obtained for total entrainment during January through December of 1979 (Table 30). Not all the annual estimates began in January, and the units in operation were different in each year; therefore, it would not be appropriate to make annual comparisons of the total entrained phytoplankton in numbers or weight. Furthermore, the above estimates were based on the assumption that the plant was operating 100% of the time and that no recirculation of discharge water occurred. Thus the monthly estimate represents a somewhat inflated value for the number and weight of phytoplankton passing through the plant during each month.

CHLOROPHYLLS AND PHAEOPHYTIN a

Chlorophylls a, b, and c and phaeophytin a data have been used 1) to monitor monthly changes in these variables with respect to observed phytoplankton densities, 2) to determine the percentage of change in these variables that would be detectable at the .05 level of significance, 3) to assess the appropriateness of the intake sampling location with all seven pumps running, 4) to assess immediate impact of entrainment on phytoplankton viability, and 5) to assess impact of entrainment on phytoplankton hours after entrainment. When phytoplankton pass through the plant, several possible alterations of the population's viability may occur. Among these are killing or damage to the organism during periods of chlorination, destruction or inhibition from heat, and stimulation of productivity due to increased temperatures or mechanical agitation.

TABLE 30. Phytoplankton entrained by the plant during 1976, 1977, 1978, and 1979. --- indicates no data.

Numbers Entrained				
Month	1976	1977	1978	1979
January	4.25×10^{17}	-----	1.79×10^{17}	3.03×10^{17}
February	1.59×10^{17}	-----	5.06×10^{16}	1.85×10^{17}
March	2.22×10^{17}	2.87×10^{17}	8.21×10^{16}	3.68×10^{17}
April	3.49×10^{17}	4.32×10^{17}	2.27×10^{17}	5.82×10^{17}
May	5.45×10^{17}	2.13×10^{17}	7.58×10^{17}	6.21×10^{17}
June	1.81×10^{17}	1.83×10^{17}	1.09×10^{18}	-----
July	9.57×10^{17}	2.53×10^{17}	1.08×10^{18}	1.85×10^{17}
August	3.79×10^{17}	2.48×10^{17}	4.05×10^{17}	3.48×10^{17}
September	5.89×10^{17}	1.88×10^{17}	3.63×10^{17}	4.63×10^{17}
October	3.28×10^{17}	3.07×10^{17}	1.26×10^{18}	7.70×10^{17}
November	3.60×10^{17}	3.56×10^{17}	9.91×10^{17}	6.82×10^{17}
December	3.46×10^{17}	2.11×10^{17}	1.36×10^{18}	1.15×10^{18}
Total	4.84×10^{18}	2.68×10^{18}	7.85×10^{18}	5.66×10^{18}

Weight Entrained (gms)				
Month	1976	1977	1978	1979
January	2.42×10^8	-----	1.02×10^8	1.73×10^8
February	9.06×10^8	-----	2.89×10^7	1.05×10^8
March	1.27×10^8	1.64×10^8	4.68×10^7	2.10×10^8
April	1.99×10^8	2.46×10^8	1.30×10^8	3.09×10^8
May	3.11×10^8	1.21×10^8	4.34×10^8	3.54×10^8
June	1.04×10^8	1.03×10^8	6.24×10^8	-----
July	5.45×10^8	1.44×10^8	6.14×10^8	1.06×10^8
August	2.16×10^8	1.41×10^8	2.30×10^8	1.98×10^8
September	3.36×10^8	1.07×10^8	2.07×10^8	2.64×10^8
October	1.87×10^8	1.75×10^8	7.15×10^8	4.39×10^8
November	2.05×10^8	2.03×10^8	5.66×10^8	3.89×10^8
December	1.97×10^8	1.20×10^8	7.73×10^8	6.56×10^8
Total	2.76×10^9	1.53×10^9	4.47×10^9	3.20×10^9

Assessment of Damage to Phytoplankton

Because the phaeophytin a to chlorophyll a ratio is relatively insensitive to changes in viability, chlorophyll data will be presented in a manner similar to the reports on the 1975, 1976, 1977, and 1978 data (Rossmann et al. 1977, Rossmann et al. 1979, Rossmann et al. 1980, Chang et al. 1981). Chlorophyll a is the most sensitive of all the variables for detecting any change in viability.

During 1979, the comparisons between the intake and discharge samples suggested that a change in phytoplankton viability was nearly the same as those noted for 1977 and 1978 (Table 31). The occurrence of significant ($P < .05$) changes in chlorophyll, phaeophytin a, and the phaeophytin a to chlorophyll a ratio during 1979, 1978, and 1977 was considerably higher than those of 1975 and 1976. This corresponded to a change in methodology; grinding was used instead of sonification and five replicates were collected rather than three. The higher occurrence of significant changes does not coincide with two-unit operation.

For the following discussion, all increases or decreases are for the discharge relative to the intake. During 1979, chlorophyll a decreased 14% of the time in all samples and 12% of the time in incubated samples (Table 32). Chlorophyll a increased 14% of the time in all samples and 30% of the time in incubated samples. For all samples, chlorophyll b (Table 33) increased 2% of the time and decreased 0% of the time. For incubated samples, it increased 10% of the time and decreased 0% of the time. For all samples, chlorophyll c (Table 34) decreased in 5% of the samples and increased in 9% of them. Incubated samples showed increases 10% of the time and showed decreases 0% of the time. For all samples, phaeophytin a (Table 35) increased 9% of the time and decreased 2% of the time. For the 1978 incubated samples, phaeophytin a did

TABLE 31. Changes in viability noted by comparison of chlorophyll data from the discharges with those from the intake.

Year	% of Comparisons Showing Increase at the Discharge	% of Comparisons Showing Decrease at the Discharge
1975	2	4
1976	4	5
1977	1	16
1978	9	9
1979	9	5

not statistically increase or decrease between intake and discharge. In 1979, the phaeophytin a/chlorophyll a ratio (Table 36) increased 7% of the time and decreased 0% of the time. For the 1979 incubated samples, the ratio did not statistically increase or decrease between intake and discharge.

With the exception of 1977, when the character of the entrained phytoplankton community was such that a probable negative impact was noted, no consistent viability increase or decrease has been observed which can be attributed to the nuclear power plant.

Monthly Variation of the Chlorophylls and Phaeophytin a

Figures 15 through 19 illustrate the variation of chlorophyll a, chlorophyll b, chlorophyll c, phaeophytin a, and the phaeophytin a to chlorophyll a ratio during 1979 at the intake forebay of the Donald C. Cook Nuclear Plant. Chlorophylls a and c were relatively high during April, May, and

TABLE 32. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	0.303E+01	0.859E-01			
01/08/79	1916	D1	0	0.305E+01	0.629E-01			
01/08/79	1948	D2	0	0.317E+01	0.952E-01	INTAKE VS DISCHARGE	0.834E+00	0.461E+00
01/08/79	1930	I5	36	0.301E+01	0.106E+00			
01/08/79	1916	D1	36	0.304E+01	0.726E-01			
01/08/79	1948	D2	36	0.287E+01	0.121E+00	INTAKE VS DISCHARGE	0.772E+00	0.488E+00
01/09/79	0731	I5	0	0.318E+01	0.606E-01			
01/09/79	0716	D1	0	0.300E+01	0.750E-01			
01/09/79	0740	D2	0	0.329E+01	0.829E-01	INTAKE VS DISCHARGE	0.398E+01	0.484E-01
01/09/79	1208	I5	0	0.323E+01	0.147E+00			
01/09/79	1155	D1	0	0.292E+01	0.863E-01			
01/09/79	1219	D2	0	0.291E+01	0.140E+00	INTAKE VS DISCHARGE	0.210E+01	0.175E+00
02/12/79	2044	I5	0	0.170E+01	0.459E-01			
02/12/79	1958	D1	0	0.151E+01	0.132E+00			
02/12/79	2022	D2	0	0.148E+01	0.863E-01	INTAKE VS DISCHARGE	0.157E+01	0.250E+00
02/12/79	2044	I5	36	0.166E+01	0.101E+00			
02/12/79	1958	D1	36	0.159E+01	0.168E+00			
02/12/79	2022	D2	36	0.111E+01	0.216E+00	INTAKE VS DISCHARGE	0.343E+01	0.749E-01
02/13/79	0644	I5	0	0.146E+01	0.251E+00			
02/13/79	0612	D1	0	0.162E+01	0.426E-01			
02/13/79	0628	D2	0	0.164E+01	0.194E+00	INTAKE VS DISCHARGE	0.348E+00	0.715E+00
02/13/79	1225	I5	0	0.168E+01	0.129E+00			
02/13/79	1145	D1	0	0.148E+01	0.991E-01			
02/13/79	1158	D2	0	0.907E+00	0.225E+00	INTAKE VS DISCHARGE	0.621E+01	0.150E-01
03/05/79	2025	I5	0	0.240E+01	0.180E+00			
03/05/79	2048	D1	0	0.287E+01	0.717E-01			
03/05/79	2102	D2	0	0.290E+01	0.195E+00	INTAKE VS DISCHARGE	0.314E+01	0.811E-01
03/05/79	2025	I5	36	0.300E+01	0.154E+00			
03/05/79	2048	D1	36	0.263E+01	0.717E-01			
03/05/79	2102	D2	36	0.245E+01	0.208E+00	INTAKE VS DISCHARGE	0.335E+01	0.711E-01
03/06/79	0620	I5	0	0.257E+01	0.670E-01			
03/06/79	0552	D1	0	0.269E+01	0.825E-01			
03/06/79	0605	D2	0	0.259E+01	0.722E-01	INTAKE VS DISCHARGE	0.696E+00	0.522E+00

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TABLE 32. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTRI1-1, I3=MTRI1-3, I5=MTRI1-5, I6=MTRI1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	0.254E+01	0.430E-01			
03/06/79	1238	D1	0	0.224E+01	0.132E+00			
03/06/79	1210	D2	0	0.266E+01	0.233E+00	INTAKE VS DISCHARGE	0.204E+01	0.182E+00
04/09/79	2127	I5	0	0.995E+01	0.131E+00			
04/09/79	2122	D2	0	0.106E+02	0.116E+00	INTAKE VS DISCHARGE	0.131E+02	0.941E-02
04/09/79	2127	I5	32	0.947E+01	0.423E+00			
04/09/79	2122	D2	32	0.761E+01	0.518E+00	INTAKE VS DISCHARGE	0.772E+01	0.246E-01
04/10/79	0429	I5	0	0.125E+02	0.474E+00			
04/10/79	0418	D2	0	0.136E+02	0.372E+00	INTAKE VS DISCHARGE	0.333E+01	0.105E+00
04/10/79	1136	I5	0	0.102E+02	0.371E+00			
04/10/79	1132	D2	0	0.113E+02	0.305E+00	INTAKE VS DISCHARGE	0.541E+01	0.487E-01
05/07/79	2200	I5	0	0.102E+02	0.413E+00			
05/07/79	2201	D2	0	0.977E+01	0.269E+00	INTAKE VS DISCHARGE	0.847E+00	0.391E+00
05/07/79	2229	I5	36	0.111E+02	0.980E-01			
05/07/79	2229	D2	36	0.106E+02	0.303E+00	INTAKE VS DISCHARGE	0.285E+01	0.129E+00
05/08/79	0327	I5	0	0.113E+02	0.185E+00			
05/08/79	0330	D2	0	0.112E+02	0.308E+00	INTAKE VS DISCHARGE	0.174E+00	0.687E+00
05/08/79	1208	I5	0	0.105E+02	0.261E+00			
05/08/79	1205	D2	0	0.103E+02	0.268E+00	INTAKE VS DISCHARGE	0.298E+00	0.602E+00
07/10/79	2302	I5	0	0.184E+01	0.167E+00			
07/10/79	2302	D2	0	0.161E+01	0.197E+00	INTAKE VS DISCHARGE	0.772E+00	0.412E+00
07/10/79	2402	I5	32	0.176E+01	0.279E+00			
07/10/79	2402	D2	32	0.120E+01	0.190E+00	INTAKE VS DISCHARGE	0.302E+01	0.126E+00
07/10/79	0252	I5	0	0.183E+01	0.352E+00			
07/10/79	0249	D2	0	0.171E+01	0.545E+00	INTAKE VS DISCHARGE	0.390E-01	0.837E+00
07/10/79	1208	I5	0	0.523E+00	0.195E+00			
07/10/79	1205	D2	0	0.169E+01	0.211E+00	INTAKE VS DISCHARGE	0.165E+02	0.441E-02
08/06/79	2217	I5	0	0.170E+01	0.841E-01			
08/06/79	2223	D1	0	0.146E+01	0.620E-01			
08/07/79	0004	D2	0	0.152E+01	0.108E+00	INTAKE VS DISCHARGE	0.228E+01	0.150E+00
08/06/79	2217	I5	36	0.134E+01	0.841E-01			
08/06/79	2223	D1	36	0.129E+01	0.637E-01			
08/07/79	0004	D2	36	0.168E+01	0.726E-01	INTAKE VS DISCHARGE	0.826E+01	0.638E-02

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TABLE 32. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	0.200E+01	0.107E+00			
08/07/79	0335	D1	0	0.183E+01	0.614E-01			
08/07/79	0340	D2	0	0.166E+01	0.716E-01	INTAKE VS DISCHARGE	0.452E+01	0.451E-01
08/07/79	1210	I5	0	0.124E+01	0.122E+00			
08/07/79	1212	D1	0	0.101E+01	0.559E-01			
08/07/79	1220	D2	0	0.115E+01	0.146E+00	INTAKE VS DISCHARGE	0.114E+01	0.357E+00
09/10/79	2048	I5	0	0.251E+01	0.210E+00			
09/10/79	2048	D2	0	0.230E+01	0.169E+00	INTAKE VS DISCHARGE	0.618E+00	0.459E+00
09/10/79	2048	I5	33	0.185E+01	0.873E-01			
09/11/79	0520	D1	28	0.274E+01	0.190E+00			
09/10/79	2048	D2	33	0.230E+01	0.173E+00	INTAKE VS DISCHARGE	0.937E+01	0.598E-02
09/11/79	0455	I4	0	0.359E+01	0.128E+00			
09/11/79	0508	D1	0	0.292E+01	0.112E+00			
09/11/79	0455	D2	0	0.338E+01	0.109E+00	INTAKE VS DISCHARGE	0.866E+01	0.549E-02
09/11/79	1210	I5	0	0.354E+01	0.767E-01			
09/11/79	1204	D1	0	0.330E+01	0.129E+00			
09/11/79	1202	D2	0	0.355E+01	0.849E-01	INTAKE VS DISCHARGE	0.216E+01	0.163E+00
10/08/79	2025	I5	0	0.387E+01	0.178E+00			
10/08/79	2010	D1	0	0.388E+01	0.939E-01			
10/08/79	2007	D2	0	0.385E+01	0.206E+00	INTAKE VS DISCHARGE	0.625E-02	0.992E+00
10/08/79	2025	I5	36	0.355E+01	0.135E+00			
10/08/79	2010	D1	36	0.362E+01	0.222E+00			
10/08/79	2007	D2	36	0.428E+01	0.153E+00			
10/09/79	0552	I5	0	0.533E+01	0.230E+00	INTAKE VS DISCHARGE	0.510E+01	0.281E-01
10/09/79	0534	D1	0	0.497E+01	0.257E+00			
10/09/79	0537	D2	0	0.499E+01	0.175E+00	INTAKE VS DISCHARGE	0.761E+00	0.493E+00
10/09/79	1220	I5	0	0.640E+01	0.233E+00			
10/09/79	1204	D1	0	0.635E+01	0.104E+00			
10/09/79	1205	D2	0	0.428E+01	0.479E+00	INTAKE VS DISCHARGE	0.169E+02	0.806E-03
11/12/79	1903	I5	0	0.397E+01	0.863E-01			
11/12/79	1903	D1	0	0.451E+01	0.137E+00	INTAKE VS DISCHARGE	0.123E+02	0.109E-01
11/12/79	1903	I5	38	0.440E+01	0.687E-01			
11/12/79	1903	D1	38	0.424E+01	0.174E+00	INTAKE VS DISCHARGE	0.814E+00	0.400E+00

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TABLE 32. MEAN CHLOROPHYLL A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5	0	5	0.429E+01	0.767E-01		
11/13/79	0603	D1	0	4	0.402E+01	0.603E-01	INTAKE VS DISCHARGE	0.307E-01
11/13/79	1235	I5	0	5	0.456E+01	0.114E+00		
11/13/79	1226	D1	0	5	0.445E+01	0.133E+00	INTAKE VS DISCHARGE	0.565E+00
12/10/79	1854	I5	0	5	0.115E+02	0.246E+00		
12/10/79	1905	D1	0	5	0.111E+02	0.121E+00	INTAKE VS DISCHARGE	0.131E+00
12/11/79	0622	I5	0	5	0.114E+02	0.150E+00		
12/11/79	0626	D1	0	5	0.111E+02	0.490E-01	INTAKE VS DISCHARGE	0.775E-01
12/11/79	1200	I5	0	5	0.112E+02	0.143E+00		
12/11/79	1200	D1	0	5	0.110E+02	0.107E+00	INTAKE VS DISCHARGE	0.215E+00

TABLE 33. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	0.166E+00	0.595E-01			
01/08/79	1916	D1	0	0.150E-01	0.125E-01			
01/08/79	1948	D2	0	0.570E-01	0.339E-01	INTAKE VS DISCHARGE	0.377E+01	0.546E-01
01/08/79	1930	I5	36	0.453E-01	0.221E-01			
01/08/79	1916	D1	36	0.194E-01	0.178E-01			
01/08/79	1948	D2	36	0.200E-02	0.200E-02	INTAKE VS DISCHARGE	0.191E+01	0.195E+00
01/09/79	0731	I5	0	0.228E-02	0.228E-02			
01/09/79	0716	D1	0	0.181E-01	0.174E-01			
01/09/79	0740	D2	0	0.0	0.0	INTAKE VS DISCHARGE	0.943E+00	0.419E+00
01/09/79	1208	I5	0	0.231E-01	0.231E-01			
01/09/79	1155	D1	0	0.330E-01	0.221E-01			
01/09/79	1219	D2	0	0.173E-01	0.119E-01	INTAKE VS DISCHARGE	0.160E+00	0.850E+00
02/12/79	2044	I5	0	0.615E-01	0.375E-01			
02/12/79	1958	D1	0	0.719E-01	0.325E-01			
02/12/79	2022	D2	0	0.376E-01	0.128E-01	INTAKE VS DISCHARGE	0.354E+00	0.709E+00
02/12/79	2044	I5	36	0.102E+00	0.415E-01			
02/12/79	1958	D1	36	0.314E-01	0.190E-01			
02/12/79	2022	D2	36	0.283E-01	0.135E-01	INTAKE VS DISCHARGE	0.194E+01	0.196E+00
02/13/79	0644	I5	0	0.575E-01	0.129E-01			
02/13/79	0612	D1	0	0.101E+00	0.191E-01			
02/13/79	0628	D2	0	0.982E-01	0.342E-01	INTAKE VS DISCHARGE	0.819E+00	0.474E+00
02/13/79	1225	I5	0	0.129E+00	0.243E-01			
02/13/79	1145	D1	0	0.137E+00	0.210E-01			
02/13/79	1158	D2	0	0.568E-01	0.135E-01	INTAKE VS DISCHARGE	0.482E+01	0.301E-01
03/05/79	2025	I5	0	0.321E-01	0.171E-01			
03/05/79	2048	D1	0	0.363E-01	0.165E-01			
03/05/79	2102	D2	0	0.571E-01	0.272E-01	INTAKE VS DISCHARGE	0.410E+00	0.674E+00
03/05/79	2025	I5	36	0.152E-01	0.975E-02			
03/05/79	2048	D1	36	0.578E-01	0.190E-01			
03/05/79	2102	D2	36	0.582E-02	0.522E-02	INTAKE VS DISCHARGE	0.474E+01	0.313E-01
03/06/79	0620	I5	0	0.489E-01	0.959E-02			
03/06/79	0552	D1	0	0.317E-01	0.123E-01			
03/06/79	0605	D2	0	0.458E-01	0.218E-01	INTAKE VS DISCHARGE	0.320E+00	0.733E+00

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TABLE 33. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	0.193E-01	0.608E-02			
03/06/79	1238	D1	0	0.470E-01	0.431E-01			
03/06/79	1210	D2	0	0.481E-01	0.240E-01	INTAKE VS DISCHARGE	0.412E+00	0.674E+00
04/09/79	2127	I5	0	0.830E-01	0.571E-01			
04/09/79	2122	D2	0	0.477E-01	0.382E-01	INTAKE VS DISCHARGE	0.284E+00	0.612E+00
04/09/79	2127	I5	32	0.925E-01	0.504E-01			
04/09/79	2122	D2	32	0.681E-01	0.442E-01	INTAKE VS DISCHARGE	0.132E+00	0.720E+00
04/10/79	0429	I5	0	0.107E-01	0.107E-01			
04/10/79	0418	D2	0	0.101E+00	0.670E-01	INTAKE VS DISCHARGE	0.177E+01	0.220E+00
04/10/79	1136	I5	0	0.344E-01	0.305E-01			
04/10/79	1132	D2	0	0.120E+00	0.764E-01	INTAKE VS DISCHARGE	0.108E+01	0.330E+00
05/07/79	2200	I5	0	0.478E-01	0.277E-01			
05/07/79	2201	D2	0	0.182E-01	0.182E-01	INTAKE VS DISCHARGE	0.858E+00	0.388E+00
05/07/79	2229	I5	36	0.0	0.0			
05/07/79	2229	D2	36	0.435E-01	0.345E-01	INTAKE VS DISCHARGE	0.159E+01	0.242E+00
05/08/79	0327	I5	0	0.227E-01	0.227E-01			
05/08/79	0330	D2	0	0.130E+00	0.754E-01	INTAKE VS DISCHARGE	0.187E+01	0.220E+00
05/08/79	1208	I5	0	0.280E-04	0.280E-04			
05/08/79	1205	D2	0	0.0	0.0	INTAKE VS DISCHARGE	0.100E+01	0.348E+00
07/10/79	2302	I5	0	0.0	0.0			
07/10/79	2302	D2	0	0.218E-01	0.214E-01	INTAKE VS DISCHARGE	0.135E+01	0.285E+00
07/10/79	2402	I5	32	0.393E-01	0.341E-01			
07/10/79	2402	D2	32	0.288E-01	0.165E-01	INTAKE VS. DISCHARGE	0.888E-01	0.765E+00
07/10/79	0252	I5	0	0.213E-01	0.191E-01			
07/10/79	0249	D2	0	0.384E-01	0.239E-01	INTAKE VS DISCHARGE	0.324E+00	0.595E+00
07/10/79	1208	I5	0	0.393E-01	0.955E-02			
07/10/79	1205	D2	0	0.334E-01	0.334E-01	INTAKE VS DISCHARGE	0.290E-01	0.855E+00
08/06/79	2217	I5	0	0.420E-02	0.420E-02			
08/06/79	2223	D1	0	0.194E-01	0.138E-01			
08/07/79	0004	D2	0	0.900E-03	0.900E-03	INTAKE VS DISCHARGE	0.121E+01	0.337E+00
08/06/79	2217	I5	36	0.0	0.0			
08/06/79	2223	D1	36	0.140E-01	0.861E-02			
08/07/79	0004	D2	36	0.438E-01	0.975E-02	INTAKE VS DISCHARGE	0.888E+01	0.508E-02

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TABLE 33. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	0.194E-01	0.969E-02			
08/07/79	0335	D1	0	0.538E-01	0.287E-01			
08/07/79	0340	D2	0	0.898E-02	0.438E-02	INTAKE VS DISCHARGE	0.193E+01	0.202E+00
08/07/79	1210	I5	0	0.110E-01	0.438E-02			
08/07/79	1212	D1	0	0.589E-02	0.588E-02			
08/07/79	1220	D2	0	0.977E-02	0.977E-02	INTAKE VS DISCHARGE	0.176E+00	0.837E+00
09/10/79	2048	I5	0	0.0	0.0			
09/10/79	2048	D2	0	0.104E-01	0.104E-01	INTAKE VS DISCHARGE	0.100E+01	0.348E+00
09/10/79	2048	I5	33	0.440E-02	0.200E-02			
09/11/79	0520	D1	28	0.887E-02	0.888E-02			
09/10/79	2048	D2	33	0.829E-01	0.327E-01	INTAKE VS DISCHARGE	0.586E+01	0.218E-01
09/11/79	0455	I4	0	0.0	0.0			
09/11/70	0508	D1	0	0.274E-02	0.274E-02			
09/11/79	0455	D2	0	0.178E-01	0.178E-01	INTAKE VS DISCHARGE	0.849E+00	0.454E+00
09/11/79	1210	I5	0	0.0	0.0			
09/11/79	1204	D1	0	0.171E-01	0.171E-01			
09/11/79	1202	D2	0	0.816E-02	0.816E-02	INTAKE VS DISCHARGE	0.739E+00	0.502E+00
10/08/79	2025	I5	0	0.190E-02	0.190E-02			
10/08/79	2010	D1	0	0.628E+00	0.474E+00			
10/08/79	2007	D2	0	0.484E-01	0.375E-01	INTAKE VS DISCHARGE	0.211E+01	0.169E+00
10/08/79	2025	I5	36	0.310E-01	0.310E-01			
10/08/79	2010	D1	36	0.800E-01	0.395E-01			
10/08/79	2007	D2	36	0.118E+00	0.372E-01	INTAKE VS DISCHARGE	0.131E+01	0.309E+00
10/09/79	0552	I5	0	0.175E-01	0.175E-01			
10/09/70	0534	D1	0	0.196E+00	0.154E+00			
10/09/79	0537	D2	0	0.106E-01	0.106E-01	INTAKE VS DISCHARGE	0.122E+01	0.334E+00
10/09/79	1220	I5	0	0.529E-01	0.513E-01			
10/09/79	1204	D1	0	0.129E+00	0.264E-01			
10/09/79	1205	D2	0	0.412E-01	0.255E-01	INTAKE VS DISCHARGE	0.159E+01	0.248E+00
11/12/79	1903	I5	0	0.200E-04	0.200E-04			
11/12/79	1903	D1	0	0.0	0.0	INTAKE VS DISCHARGE	0.778E+00	0.410E+00
11/12/79	1903	I5	38	0.0	0.0			
11/12/79	1903	D1	38	0.800E-04	0.800E-04	INTAKE VS DISCHARGE	0.130E+01	0.293E+00

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TABLE 33. MEAN CHLOROPHYLL B CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5	0	5	0.185E-02	0.185E-02		
11/13/79	0603	D1	0	4	0.0	0.0	INTAKE VS DISCHARGE	0.778E+00
11/13/79	1235	I5	0	5	0.695E-02	0.500E-02		0.410E+00
11/13/79	1226	D1	0	5	0.457E-01	0.257E-01	INTAKE VS DISCHARGE	0.219E+01
12/10/79	1854	I5	0	5	0.268E-01	0.268E-01		0.177E+00
12/10/79	1905	D1	0	5	0.679E-01	0.523E-01	INTAKE VS DISCHARGE	0.489E+00
12/11/79	0622	I5	0	5	0.916E-03	0.916E-03		0.508E+00
12/11/79	0626	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.956E+00
12/11/79	1200	I5	0	5	0.200E-04	0.200E-04		0.359E+00
12/11/79	1200	D1	0	5	0.866E-02	0.866E-02	INTAKE VS DISCHARGE	0.100E+01
								0.348E+00

TABLE 34. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	0.289E+00	0.878E-01			
01/08/79	1916	D1	0	0.587E+00	0.791E-01			
01/08/79	1948	D2	0	0.787E+00	0.123E+00	INTAKE VS DISCHARGE	0.652E+01	0.130E-01
01/08/79	1930	I5	36	0.581E+00	0.620E-01			
01/08/79	1916	D1	36	0.802E+00	0.155E+00			
01/08/79	1948	D2	36	0.623E+00	0.282E-01	INTAKE VS DISCHARGE	0.172E+01	0.225E+00
01/08/79	0731	I5	0	0.583E+00	0.174E-01			
01/09/79	0716	D1	0	0.546E+00	0.530E-01			
01/09/79	0740	D2	0	0.624E+00	0.269E-01	INTAKE VS DISCHARGE	0.117E+01	0.344E+00
01/09/79	1208	I5	0	0.484E+00	0.120E+00			
01/09/79	1155	D1	0	0.517E+00	0.277E-01			
01/09/79	1219	D2	0	0.625E+00	0.540E-01	INTAKE VS DISCHARGE	0.975E+00	0.412E+00
02/12/79	2044	I5	0	0.660E+00	0.885E-01			
02/12/79	1958	D1	0	0.445E+00	0.578E-01			
02/12/79	2022	D2	0	0.390E+00	0.142E-01	INTAKE VS DISCHARGE	0.538E+01	0.224E-01
02/12/79	2044	I5	36	0.593E+00	0.134E+00			
02/12/79	1958	D1	36	0.336E+00	0.381E-01			
02/12/79	2022	D2	36	0.420E+00	0.465E-01	INTAKE VS DISCHARGE	0.196E+01	0.193E+00
02/13/79	0644	I5	0	0.427E+00	0.118E+00			
02/13/79	0612	D1	0	0.689E+00	0.422E-01			
02/13/79	0628	D2	0	0.570E+00	0.820E-01	INTAKE VS DISCHARGE	0.293E+01	0.107E+00
02/13/79	1225	I5	0	0.680E+00	0.647E-01			
02/13/79	1145	D1	0	0.653E+00	0.484E-01			
02/13/79	1158	D2	0	0.481E+00	0.626E-01	INTAKE VS DISCHARGE	0.337E+01	0.702E-01
03/05/79	2025	I5	0	0.552E+00	0.439E-01			
03/05/79	2048	D1	0	0.712E+00	0.462E-01			
03/05/79	2102	D2	0	0.710E+00	0.111E+00	INTAKE VS DISCHARGE	0.155E+01	0.252E+00
03/05/79	2025	I5	36	0.718E+00	0.352E-01			
03/05/79	2048	D1	36	0.524E+00	0.738E-01			
03/05/79	2102	D2	36	0.683E+00	0.856E-01	INTAKE VS DISCHARGE	0.230E+01	0.144E+00
03/06/79	0620	I5	0	0.631E+00	0.615E-01			
03/06/79	0552	D1	0	0.728E+00	0.261E-01			
03/06/79	0605	D2	0	0.607E+00	0.459E-01	INTAKE VS DISCHARGE	0.219E+01	0.160E+00

CONTINUED

TABLE 34. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	0.631E+00	0.851E-01			
03/06/79	1238	D1	0	0.686E+00	0.163E+00			
03/06/79	1210	D2	0	0.701E+00	0.645E-01	INTAKE VS DISCHARGE	0.123E+00	0.880E+00
04/09/79	2127	I5	0	0.151E+01	0.133E+00			
04/09/79	2122	D2	0	0.146E+01	0.420E-01	INTAKE VS DISCHARGE	0.132E+00	0.721E+00
04/09/79	2127	I5	32	0.135E+01	0.112E+00			
04/09/79	2122	D2	32	0.120E+01	0.134E+00	INTAKE VS DISCHARGE	0.782E+00	0.405E+00
04/10/79	0429	I5	0	0.178E+01	0.634E-01			
04/10/79	0418	D2	0	0.161E+01	0.922E-01	INTAKE VS DISCHARGE	0.236E+01	0.163E+00
04/10/79	1136	I5	0	0.156E+01	0.250E+00			
04/10/79	1132	D2	0	0.157E+01	0.919E-01	INTAKE VS DISCHARGE	0.223E-02	0.953E+00
05/07/79	2200	I5	0	0.170E+01	0.110E+00			
05/07/79	2201	D2	0	0.177E+01	0.541E-01	INTAKE VS DISCHARGE	0.365E+00	0.567E+00
05/07/79	2229	I5	36	0.173E+01	0.798E-01			
05/07/79	2229	D2	36	0.148E+01	0.913E-01	INTAKE VS DISCHARGE	0.432E+01	0.712E-01
05/08/79	0327	I5	0	0.187E+01	0.174E+00			
05/08/79	0330	D2	0	0.102E+01	0.373E+00	INTAKE VS DISCHARGE	0.423E+01	0.861E-01
05/08/79	1208	I5	0	0.180E+01	0.140E+00			
05/08/79	1205	D2	0	0.150E+01	0.165E+00	INTAKE VS DISCHARGE	0.183E+01	0.213E+00
07/10/79	2302	I5	0	0.286E+00	0.606E-01			
07/10/79	2302	D2	0	0.479E+00	0.944E-02	INTAKE VS DISCHARGE	0.773E+01	0.280E-01
07/10/79	2402	I5	32	0.609E+00	0.852E-01			
07/10/79	2402	D2	32	0.413E+00	0.101E+00	INTAKE VS DISCHARGE	0.206E+01	0.194E+00
07/10/79	0252	I5	0	0.550E+00	0.789E-01			
07/10/79	0249	D2	0	0.643E+00	0.104E+00	INTAKE VS DISCHARGE	0.528E+00	0.503E+00
07/10/79	1208	I5	0	0.436E+00	0.338E-01			
07/10/79	1205	D2	0	0.382E+00	0.103E+00	INTAKE VS DISCHARGE	0.256E+00	0.627E+00
08/06/79	2217	I5	0	0.290E+00	0.598E-01			
08/06/79	2223	D1	0	0.184E+00	0.762E-01			
08/07/79	0004	D2	0	0.227E+00	0.550E-01	INTAKE VS DISCHARGE	0.694E+00	0.522E+00
08/06/79	2217	I5	36	0.151E+00	0.513E-01			
08/06/79	2223	D1	36	0.213E+00	0.629E-01			
08/07/79	0004	D2	36	0.280E+00	0.365E-01	INTAKE VS DISCHARGE	0.157E+01	0.248E+00

CONTINUED

TABLE 34. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	0.404E+00	0.642E-01			
08/07/79	0335	D1	0	0.374E+00	0.474E-01			
08/07/79	0340	D2	0	0.294E+00	0.336E-01	INTAKE VS DISCHARGE	0.163E+01	0.251E+00
08/07/79	1210	I5	0	0.227E+00	0.377E-01			
08/07/79	1212	D1	0	0.201E+00	0.275E-01			
08/07/79	1220	D2	0	0.167E+00	0.804E-01	INTAKE VS DISCHARGE	0.356E+00	0.709E+00
09/10/79	2048	I5	0	0.310E+00	0.458E-01			
09/10/79	2048	D2	0	0.624E+00	0.924E-01	INTAKE VS DISCHARGE	0.929E+01	0.166E-01
09/10/79	2048	I5	33	0.220E+00	0.277E-01			
09/11/79	0520	D1	28	0.234E+00	0.549E-01			
09/10/79	2048	D2	33	0.362E+00	0.610E-01	INTAKE VS DISCHARGE	0.266E+01	0.120E+00
09/11/79	0455	I4	0	0.603E+00	0.411E-01			
09/11/70	0508	D1	0	0.427E+00	0.329E-01			
09/11/79	0455	D2	0	0.453E+00	0.418E-01	INTAKE VS DISCHARGE	0.597E+01	0.168E-01
09/11/79	1210	I5	0	0.372E+00	0.631E-01			
09/11/79	1204	D1	0	0.450E+00	0.476E-01			
09/11/79	1202	D2	0	0.393E+00	0.642E-01	INTAKE VS DISCHARGE	0.410E+00	0.675E+00
10/08/79	2025	I5	0	0.500E+00	0.612E-01			
10/08/79	2010	D1	0	0.289E+00	0.109E+00			
10/08/79	2007	D2	0	0.398E+00	0.509E-01	INTAKE VS DISCHARGE	0.202E+01	0.181E+00
10/08/79	2025	I5	36	0.364E+00	0.491E-01			
10/08/79	2010	D1	36	0.524E+00	0.973E-01			
10/08/79	2007	D2	36	0.763E+00	0.252E-01	INTAKE VS DISCHARGE	0.873E+01	0.620E-02
10/09/79	0552	I5	0	0.645E+00	0.680E-01			
10/09/70	0534	D1	0	0.107E+01	0.428E+00			
10/09/79	0537	D2	0	0.704E+00	0.785E-01	INTAKE VS DISCHARGE	0.719E+00	0.511E+00
10/09/79	1220	I5	0	0.836E+00	0.118E+00			
10/09/79	1204	D1	0	0.915E+00	0.116E+00			
10/09/79	1205	D2	0	0.740E+00	0.913E-01	INTAKE VS DISCHARGE	0.574E+00	0.582E+00
11/12/79	1903	I5	0	0.579E+00	0.391E-01			
11/12/79	1903	D1	0	0.726E+00	0.637E-01	INTAKE VS DISCHARGE	0.423E+01	0.789E-01
11/12/79	1903	I5	38	0.843E+00	0.785E-01			
11/12/79	1903	D1	38	0.882E+00	0.772E-01	INTAKE VS DISCHARGE	0.126E+00	0.727E+00

CONTINUED

TABLE 34. MEAN CHLOROPHYLL C CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5	0	5	0.912E+00	0.827E-01		
11/13/79	0603	D1	0	4	0.731E+00	0.144E-01	INTAKE VS DISCHARGE	0.977E-01
11/13/79	1235	I5	0	5	0.922E+00	0.905E-01		
11/13/79	1226	D1	0	5	0.903E+00	0.492E-01	INTAKE VS DISCHARGE	0.843E+00
12/10/79	1854	I5	0	5	0.186E+01	0.232E+00		
12/10/79	1905	D1	0	5	0.188E+01	0.166E+00	INTAKE VS DISCHARGE	0.940E+00
12/11/79	0622	I5	0	5	0.172E+01	0.801E-01		
12/11/79	0626	D1	0	5	0.152E+01	0.175E+00	INTAKE VS DISCHARGE	0.345E+00
12/11/79	1200	I5	0	5	0.181E+01	0.140E+00		
12/11/79	1200	D1	0	5	0.163E+01	0.710E-01	INTAKE VS DISCHARGE	0.280E+00

TABLE 35. MEAN PHAEOPHYTIN A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	0.200E+00	0.967E-01			
01/08/79	1916	D1	0	0.116E+00	0.402E-01			
01/08/79	1948	D2	0	0.122E+00	0.559E-01	INTAKE VS DISCHARGE	0.464E+00	0.642E+00
01/08/79	1930	I5	36	0.918E-01	0.253E-01			
01/08/79	1916	D1	36	0.218E+00	0.963E-01			
01/08/79	1948	D2	36	0.300E+00	0.134E+00	INTAKE VS DISCHARGE	0.125E+01	0.324E+00
01/09/79	0731	I5	0	0.197E+00	0.387E-01			
01/09/79	0716	D1	0	0.385E+00	0.158E+00			
01/09/79	0740	D2	0	0.716E-01	0.467E-01	INTAKE VS DISCHARGE	0.261E+01	0.116E+00
01/09/79	1208	I5	0	0.159E+00	0.986E-01			
01/09/79	1155	D1	0	0.266E+00	0.105E+00			
01/09/79	1219	D2	0	0.272E+00	0.964E-01	INTAKE VS DISCHARGE	0.373E+00	0.698E+00
02/12/79	2044	I5	0	0.205E+00	0.729E-01			
02/12/79	1958	D1	0	0.360E+00	0.165E+00			
02/12/79	2022	D2	0	0.272E+00	0.848E-01	INTAKE VS DISCHARGE	0.456E+00	0.646E+00
02/12/79	2044	I5	36	0.174E+00	0.120E+00			
02/12/79	1958	D1	36	0.140E+00	0.140E+00			
02/12/79	2022	D2	36	0.546E+00	0.236E+00	INTAKE VS DISCHARGE	0.175E+01	0.223E+00
02/13/79	0644	I5	0	0.585E+00	0.318E+00			
02/13/79	0612	D1	0	0.365E+00	0.764E-01			
02/13/79	0628	D2	0	0.270E+00	0.138E+00	INTAKE VS DISCHARGE	0.827E+00	0.471E+00
02/13/79	1225	I5	0	0.256E+00	0.152E+00			
02/13/79	1145	D1	0	0.515E+00	0.106E+00			
02/13/79	1158	D2	0	0.990E+00	0.235E+00	INTAKE VS DISCHARGE	0.465E+01	0.330E-01
03/05/79	2025	I5	0	0.990E+00	0.254E+00			
03/05/79	2048	D1	0	0.439E+00	0.127E+00			
03/05/79	2102	D2	0	0.389E+00	0.191E+00	INTAKE VS DISCHARGE	0.285E+01	0.985E-01
03/05/79	2025	I5	36	0.782E+00	0.153E+00			
03/05/79	2048	D1	36	0.925E+00	0.109E+00			
03/05/79	2102	D2	36	0.136E+01	0.331E+00	INTAKE VS DISCHARGE	0.186E+01	0.199E+00
03/06/79	0620	I5	0	0.106E+01	0.115E+00			
03/06/79	0552	D1	0	0.108E+01	0.124E+00			
03/06/79	0605	D2	0	0.126E+01	0.143E+00	INTAKE VS DISCHARGE	0.773E+00	0.488E+00

CONTINUED

TABLE 35. MEAN PHAEOPHYTIN A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	5	0.116E+01	0.693E-01		
03/06/79	1238	D1	0	4	0.158E+01	0.534E+00		
03/06/79	1210	D2	0	4	0.819E+00	0.318E+00	INTAKE VS DISCHARGE	0.122E+01 0.336E+00
04/09/79	2127	I5	0	4	0.157E+01	0.191E+00		
04/09/79	2122	D2	0	5	0.855E+00	0.112E+00	INTAKE VS DISCHARGE	0.116E+02 0.122E-01
04/09/79	2127	I5	32	5	0.228E+00	0.950E-01		
04/09/79	2122	D2	32	5	0.641E+00	0.323E+00	INTAKE VS DISCHARGE	0.151E+01 0.255E+00
04/10/79	0429	I5	0	5	0.113E+01	0.335E+00		
04/10/79	0418	D2	0	5	0.562E+00	0.134E+00	INTAKE VS DISCHARGE	0.249E+01 0.153E+00
04/10/79	1136	I5	0	5	0.639E+00	0.270E+00		
04/10/79	1132	D2	0	5	0.0	0.0	INTAKE VS DISCHARGE	0.561E+01 0.456E-01
05/07/79	2200	I5	0	4	0.201E+01	0.409E+00		
05/07/79	2201	D2	0	5	0.152E+01	0.359E+00	INTAKE VS DISCHARGE	0.843E+00 0.392E+00
05/07/79	2229	I5	36	5	0.962E+00	0.250E+00		
05/07/79	2229	D2	36	5	0.741E+00	0.330E+00	INTAKE VS DISCHARGE	0.284E+00 0.610E+00
05/08/79	0327	I5	0	4	0.769E+00	0.777E-01		
05/08/79	0330	D2	0	4	0.462E+00	0.170E+00	INTAKE VS DISCHARGE	0.269E+01 0.152E+00
05/08/79	1208	I5	0	5	0.888E+00	0.216E+00		
05/08/79	1205	D2	0	5	0.789E+00	0.133E+00	INTAKE VS DISCHARGE	0.154E+00 0.701E+00
07/10/79	2302	I5	0	5	0.138E+00	0.134E+00		
07/10/79	2302	D2	0	4	0.159E+00	0.964E-01	INTAKE VS DISCHARGE	0.149E-01 0.893E+00
07/10/79	2402	I5	32	4	0.412E+00	0.226E+00		
07/10/79	2402	D2	32	5	0.711E+00	0.167E+00	INTAKE VS DISCHARGE	0.119E+01 0.313E+00
07/10/79	0252	I5	0	4	0.559E+00	0.277E+00		
07/10/79	0249	D2	0	3	0.628E+00	0.361E+00	INTAKE VS DISCHARGE	0.239E-01 0.869E+00
07/10/79	1208	I5	0	5	0.120E+01	0.252E+00		
07/10/79	1205	D2	0	5	0.152E+00	0.958E-01	INTAKE VS DISCHARGE	0.150E+02 0.551E-02
08/06/79	2217	I5	0	5	0.102E+00	0.623E-01		
08/06/79	2223	D1	0	5	0.694E-01	0.314E-01		
08/07/79	0004	D2	0	4	0.263E+00	0.124E+00	INTAKE VS DISCHARGE	0.182E+01 0.209E+00
08/06/79	2217	I5	36	5	0.150E+00	0.774E-01		
08/06/79	2223	D1	36	5	0.178E+00	0.840E-01		
08/07/79	0004	D2	36	5	0.716E-01	0.487E-01	INTAKE VS DISCHARGE	0.594E+00 0.570E+00

CONTINUED

TABLE 35. MEAN PHAEOPHYTIN A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	0.694E+01	0.373E-01			
08/07/79	0335	D1	0	0.100E+00	0.661E-01			
08/07/79	0340	D2	0	0.251E+00	0.973E-01	INTAKE VS DISCHARGE	0.144E+01	0.287E+00
08/07/79	1210	I5	0	0.124E+00	0.818E-01			
08/07/79	1212	D1	0	0.362E-01	0.237E-01			
08/07/79	1220	D2	0	0.147E-01	0.147E-01	INTAKE VS DISCHARGE	0.117E+01	0.346E+00
09/10/79	2048	I5	0	0.437E-01	0.201E-01			
09/10/79	2048	D2	0	0.301E+00	0.142E+00	INTAKE VS DISCHARGE	0.324E+01	0.109E+00
09/10/79	2048	I5	33	0.250E+00	0.886E-01			
09/10/79	0520	D1	28	0.175E+00	0.116E+00			
09/10/79	2048	D2	33	0.480E-01	0.480E-01	INTAKE VS DISCHARGE	0.131E+01	0.312E+00
09/11/79	0455	I4	0	0.0	0.0			
09/11/79	0508	D1	0	0.248E+00	0.141E+00			
09/11/79	0455	D2	0	0.598E-01	0.487E-01	INTAKE VS DISCHARGE	0.225E+01	0.149E+00
09/11/79	1210	I5	0	0.417E-01	0.403E-01			
09/11/79	1204	D1	0	0.103E+00	0.103E+00			
09/11/79	1202	D2	0	0.341E-01	0.225E-01	INTAKE VS DISCHARGE	0.395E+00	0.684E+00
10/08/79	2025	I5	0	0.596E+00	0.154E+00			
10/08/79	2010	D1	0	0.479E+00	0.984E-01			
10/08/79	2007	D2	0	0.624E+00	0.295E+00	INTAKE VS DISCHARGE	0.120E+00	0.883E+00
10/08/79	2025	I5	36	0.184E+00	0.693E-01			
10/08/79	2010	D1	36	0.468E+00	0.226E+00			
10/08/79	2007	D2	36	0.876E-01	0.876E-01	INTAKE VS DISCHARGE	0.173E+01	0.223E+00
10/09/79	0552	I5	0	0.926E+00	0.310E+00			
10/09/79	0534	D1	0	0.931E+00	0.258E+00			
10/09/79	0537	D2	0	0.994E+00	0.138E+00	INTAKE VS DISCHARGE	0.259E-01	0.972E+00
10/09/79	1220	I5	0	0.121E+01	0.233E+00			
10/09/79	1204	D1	0	0.106E+01	0.177E+00			
10/09/79	1205	D2	0	0.200E+01	0.446E+00	INTAKE VS DISCHARGE	0.295E+01	0.954E-01
11/12/79	1903	I5	0	0.535E+00	0.108E+00			
11/12/79	1903	D1	0	0.136E+00	0.785E-01	INTAKE VS DISCHARGE	0.804E+01	0.260E-01
11/12/79	1903	I5	38	0.704E-01	0.704E-01			
11/12/79	1903	D1	38	0.250E+00	0.709E-01	INTAKE VS DISCHARGE	0.313E+01	0.120E+00

CONTINUED

TABLE 35. MEAN PHTALOPHYTIN A CONCENTRATIONS (MILLIGRAMS PER CUBIC METER) WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5	0	0.780E-01	0.610E-01	INTAKE VS DISCHARGE	0.146E+00	0.708E+00
11/13/79	0603	D1	0	0.108E+00	0.440E-01	INTAKE VS DISCHARGE	0.982E-03	0.965E+00
11/13/79	1235	I5	0	0.994E-01	0.840E-01	INTAKE VS DISCHARGE	0.0	0.100E+01
11/13/79	1236	D1	0	0.104E+00	0.104E+00	INTAKE VS DISCHARGE	0.0	0.100E+01
12/10/79	1854	I5	0	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/10/79	1905	D1	0	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	0622	I5	0	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	0626	D1	0	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	1200	I5	0	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01
12/11/79	1200	D1	0	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0	0.100E+01

December. These high concentrations reflect the spring centric diatom bloom in April and the pennate diatom blooms of May and December. Increased concentrations of chlorophyll a in October reflect increased numbers of coccoid and filamentous blue-green algae, centric diatoms, and other algae. Chlorophyll b was quite low throughout 1979. Phaeophytin a exhibited peaks in its concentration during March, April, May, and October. The phaeophytin a/chlorophyll a ratio was highest (1.22) in July.

SUMMARY

Orthophosphate concentrations in 1979 ranged from .080 to 4.2 ppb. Lowest concentrations were in February, and the highest were in November. Nitrate concentrations varied from 0.065 to 0.32 ppm, with the lowest concentration in March and the highest concentration in April. Dissolved silica concentrations were below 0.5 ppm in May, August, September, and December and ranged between 0.017 and 2.0 ppm. The highest concentration occurred in March. The lowest concentration of 0.017 ppm in May coincided with the pennate diatom bloom of that month.

Coccoid blue-green algae were low in concentration during April through July and high in concentration from September through December. Filamentous blue-green algae were less numerous than coccoid blue-green algae. The maximum count was 201 cells/mL, and occurred in July. Coccoid green algae numbers were relatively high during August through December. Filamentous green algae were above 10 cells/mL only in December. Flagellates were numerous and contributed an important share to the total annual algal population. They peaked in May, as the June sample was not collected, and maintained a relatively low density in

TABLE 36. MEAN PHAEOPHYTIN A TO CHLOROPHYLL A RATIO WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
01/08/79	1930	I5	0	0.698E-01	0.347E-01			
01/08/79	1916	D1	0	0.391E-01	0.138E-01			
01/08/79	1948	D2	0	0.400E-01	0.186E-01	INTAKE VS DISCHARGE	0.525E+00	0.607E+00
01/08/79	1930	I5	36	0.302E-01	0.821E-02			
01/08/79	1916	D1	36	0.727E-01	0.322E-01			
01/08/79	1948	D2	36	0.114E+00	0.562E-01	INTAKE VS DISCHARGE	0.124E+01	0.327E+00
01/09/79	0731	I5	0	0.615E-01	0.122E-01			
01/09/79	0716	D1	0	0.134E+00	0.581E-01			
01/09/79	0740	D2	0	0.226E-01	0.149E-01	INTAKE VS DISCHARGE	0.254E+01	0.121E+00
01/09/79	1208	I5	0	0.538E-01	0.339E-01			
01/09/79	1155	D1	0	0.950E-01	0.386E-01			
01/09/79	1219	D2	0	0.977E-01	0.340E-01	INTAKE VS DISCHARGE	0.435E+00	0.660E+00
02/12/79	2044	I5	0	0.124E+00	0.445E-01			
02/12/79	1958	D1	0	0.288E+00	0.146E+00			
02/12/79	2022	D2	0	0.195E+00	0.647E-01	INTAKE VS DISCHARGE	0.741E+00	0.500E+00
02/12/79	2044	I5	36	0.120E+00	0.862E-01			
02/12/79	1958	D1	36	0.125E+00	0.125E+00			
02/12/79	2022	D2	36	0.708E+00	0.407E+00	INTAKE VS DISCHARGE	0.205E+01	0.181E+00
02/13/79	0644	I5	0	0.525E+00	0.369E+00			
02/13/79	0612	D1	0	0.230E+00	0.509E-01			
02/13/79	0628	D2	0	0.196E+00	0.106E+00	INTAKE VS DISCHARGE	0.984E+00	0.413E+00
02/13/79	1225	I5	0	0.190E+00	0.123E+00			
02/13/79	1145	D1	0	0.376E+00	0.104E+00			
02/13/79	1158	D2	0	0.189E+01	0.820E+00	INTAKE VS DISCHARGE	0.375E+01	0.555E-01
03/05/79	2025	I5	0	0.453E+00	0.139E+00			
03/05/79	2048	D1	0	0.158E+00	0.511E-01			
03/05/79	2102	D2	0	0.153E+00	0.769E-01	INTAKE VS DISCHARGE	0.318E+01	0.790E-01
03/05/79	2025	I5	36	0.274E+00	0.660E-01			
03/05/79	2048	D1	36	0.353E+00	0.439E-01			
03/05/79	2102	D2	36	0.623E+00	0.201E+00	INTAKE VS DISCHARGE	0.214E+01	0.162E+00
03/06/79	0620	I5	0	0.414E+00	0.541E-01			
03/06/79	0552	D1	0	0.407E+00	0.569E-01			
03/06/79	0605	D2	0	0.493E+00	0.635E-01	INTAKE VS DISCHARGE	0.686E+00	0.526E+00

CONTINUED

TABLE 36. MEAN PHAEOPHYTIN A TO CHLOROPHYLL A RATIO WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
03/06/79	1254	I5	0	0.457E+00	0.316E-01			
03/06/79	1238	D1	0	0.750E+00	0.301E+00			
03/06/79	1210	D2	0	0.352E+00	0.166E+00	INTAKE VS DISCHARGE	0.120E+01	0.343E+00
04/09/79	2127	I5	0	0.158E+00	0.196E-01			
04/09/79	2122	D2	0	0.811E-01	0.110E-01	INTAKE VS DISCHARGE	0.131E+02	0.942E-02
04/09/79	2127	I5	32	0.236E-01	0.956E-02			
04/09/79	2122	D2	32	0.886E-01	0.451E-01	INTAKE VS DISCHARGE	0.199E+01	0.196E+00
04/10/79	0429	I5	0	0.949E-01	0.294E-01			
04/10/79	0418	D2	0	0.416E-01	0.999E-02	INTAKE VS DISCHARGE	0.294E+01	0.124E+00
04/10/79	1136	I5	0	0.650E-01	0.275E-01			
04/10/79	1132	D2	0	0.0	0.0	INTAKE VS DISCHARGE	0.558E+01	0.460E-01
05/07/79	2200	I5	0	0.203E+00	0.464E-01			
05/07/79	2201	D2	0	0.158E+00	0.392E-01	INTAKE VS DISCHARGE	0.545E+00	0.488E+00
05/07/79	2229	I5	36	0.866E-01	0.227E-01			
05/07/79	2229	D2	36	0.739E-01	0.348E-01	INTAKE VS DISCHARGE	0.930E-01	0.759E+00
05/08/79	0327	I5	0	0.675E-01	0.587E-02			
05/08/79	0330	D2	0	0.425E-01	0.161E-01	INTAKE VS DISCHARGE	0.212E+01	0.196E+00
05/08/79	1208	I5	0	0.862E-01	0.227E-01			
05/08/79	1205	D2	0	0.776E-01	0.145E-01	INTAKE VS DISCHARGE	0.101E+00	0.751E+00
07/10/79	2302	I5	0	0.918E-01	0.896E-01			
07/10/79	2302	D2	0	0.120E+00	0.703E-01	INTAKE VS DISCHARGE	0.554E-01	0.808E+00
07/10/79	2402	I5	32	0.316E+00	0.197E+00			
07/10/79	2402	D2	32	0.754E+00	0.263E+00	INTAKE VS. DISCHARGE	0.161E+01	0.245E+00
07/10/79	0252	I5	0	0.408E+00	0.213E+00			
07/10/79	0249	D2	0	0.713E+00	0.552E+00	INTAKE VS DISCHARGE	0.337E+00	0.588E+00
07/10/79	1208	I5	0	0.926E+01	0.646E+01			
07/10/79	1205	D2	0	0.124E+00	0.781E-01	INTAKE VS DISCHARGE	0.200E+01	0.195E+00
08/06/79	2217	I5	0	0.668E-01	0.410E-01			
08/06/79	2223	D1	0	0.490E-01	0.229E-01	INTAKE VS DISCHARGE	0.170E+01	0.228E+00
08/07/79	0004	D2	0	0.194E+00	0.104E+00			
08/06/79	2217	I5	36	0.129E+00	0.711E-01	INTAKE VS DISCHARGE		
08/06/79	2223	D1	36	0.148E+00	0.686E-01			
08/07/79	0004	D2	36	0.468E-01	0.316E-01	INTAKE VS DISCHARGE	0.807E+00	0.472E+00

CONTINUED

TABLE 36. MEAN PHAEOPHYTIN A TO CHLOROPHYLL A RATIO WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
08/07/79	0347	I5	0	0.370E-01	0.205E-01			
08/07/79	0335	D1	0	0.582E-01	0.401E-01			
08/07/79	0340	D2	0	0.161E+00	0.669E-01	INTAKE VS DISCHARGE	0.150E+01	0.276E+00
08/07/79	1210	I5	0	0.127E+00	0.820E-01			
08/07/79	1212	D1	0	0.415E-01	0.275E-01			
08/07/79	1220	D2	0	0.183E-01	0.183E-01	INTAKE VS DISCHARGE	0.110E+01	0.369E+00
09/10/79	2048	I5	0	0.194E-01	0.857E-02			
09/10/79	2048	D2	0	0.150E+00	0.745E-01	INTAKE VS DISCHARGE	0.305E+01	0.118E+00
09/10/79	2048	I5	33	0.143E+00	0.508E-01			
09/11/79	0520	D1	28	0.717E-01	0.493E-01			
09/10/79	2048	D2	33	0.243E-01	0.243E-01	INTAKE VS DISCHARGE	0.183E+01	0.212E+00
09/11/79	0455	I4	0	0.0	0.0			
09/11/70	0508	D1	0	0.928E-01	0.541E-01			
09/11/79	0455	D2	0	0.189E-01	0.155E-01	INTAKE VS DISCHARGE	0.227E+01	0.147E+00
09/11/79	1210	I5	0	0.126E-01	0.122E-01			
09/11/79	1204	D1	0	0.343E-01	0.342E-01			
09/11/79	1202	D2	0	0.101E-01	0.669E-02	INTAKE VS DISCHARGE	0.465E+00	0.642E+00
10/08/79	2025	I5	0	0.162E+00	0.469E-01			
10/08/79	2010	D1	0	0.125E+00	0.267E-01			
10/08/79	2007	D2	0	0.182E+00	0.945E-01	INTAKE VS DISCHARGE	0.175E+00	0.838E+00
10/08/79	2025	I5	36	0.541E-01	0.206E-01			
10/08/79	2010	D1	36	0.148E+00	0.760E-01			
10/08/79	2007	D2	36	0.224E-01	0.224E-01	INTAKE VS DISCHARGE	0.178E+01	0.215E+00
10/09/79	0552	I5	0	0.181E+00	0.629E-01			
10/09/70	0534	D1	0	0.201E+00	0.660E-01			
10/09/79	0537	D2	0	0.204E+00	0.355E-01	INTAKE VS DISCHARGE	0.448E-01	0.952E+00
10/09/79	1220	I5	0	0.195E+00	0.411E-01			
10/09/79	1204	D1	0	0.169E+00	0.294E-01			
10/09/79	1205	D2	0	0.520E+00	0.163E+00	INTAKE VS DISCHARGE	0.490E+01	0.311E-01
11/12/79	1903	I5	0	0.137E+00	0.303E-01			
11/12/79	1903	D1	0	0.315E-01	0.182E-01	INTAKE VS DISCHARGE	0.777E+01	0.278E-01
11/12/79	1903	I5	38	0.159E-01	0.159E-01			
11/12/79	1903	D1	38	0.594E-01	0.172E-01	INTAKE VS DISCHARGE	0.342E+01	0.107E+00

CONTINUED

TABLE 36.. MEAN PHAEOPHYTIN A TO CHLOROPHYLL A RATIO WITH STANDARD ERRORS AND COMPARISON OF MEANS USING ONE-WAY ANALYSIS OF VARIANCE. THE INC. COLUMN IS SAMPLE TYPE (I1=MTR1-1, I3=MTR1-3, I5=MTR1-5, I6=MTR1-6, D=DISCHARGE) AND NUMBER OF HOURS AFTER COLLECTION IT WAS INCUBATED.

DATE	TIME	INC.	SAMPLES	MEAN	STANDARD ERROR	COMPARISON BETWEEN	F-STATISTIC	SIGNIFICANCE
11/13/79	0604	I5	0	5	0.189E-01	0.150E-01		
11/13/79	0603	D1	0	4	0.268E-01	0.107E-01	INTAKE VS DISCHARGE	0.166E+00
11/13/79	1235	I5	0	5	0.237E-01	0.202E-01		0.692E+00
11/13/79	1226	D1	0	5	0.258E-01	0.258E-01	INTAKE VS DISCHARGE	0.429E-02
12/10/79	1854	I5	0	5	0.200E-04	0.200E-04		0.938E+00
12/10/79	1905	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0
12/11/79	0622	I5	0	5	0.200E-04	0.200E-04		0.100E+01
12/11/79	0626	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0
12/11/79	1200	I5	0	5	0.200E-04	0.200E-04		0.100E+01
12/11/79	1200	D1	0	5	0.200E-04	0.200E-04	INTAKE VS DISCHARGE	0.0
								0.100E+01

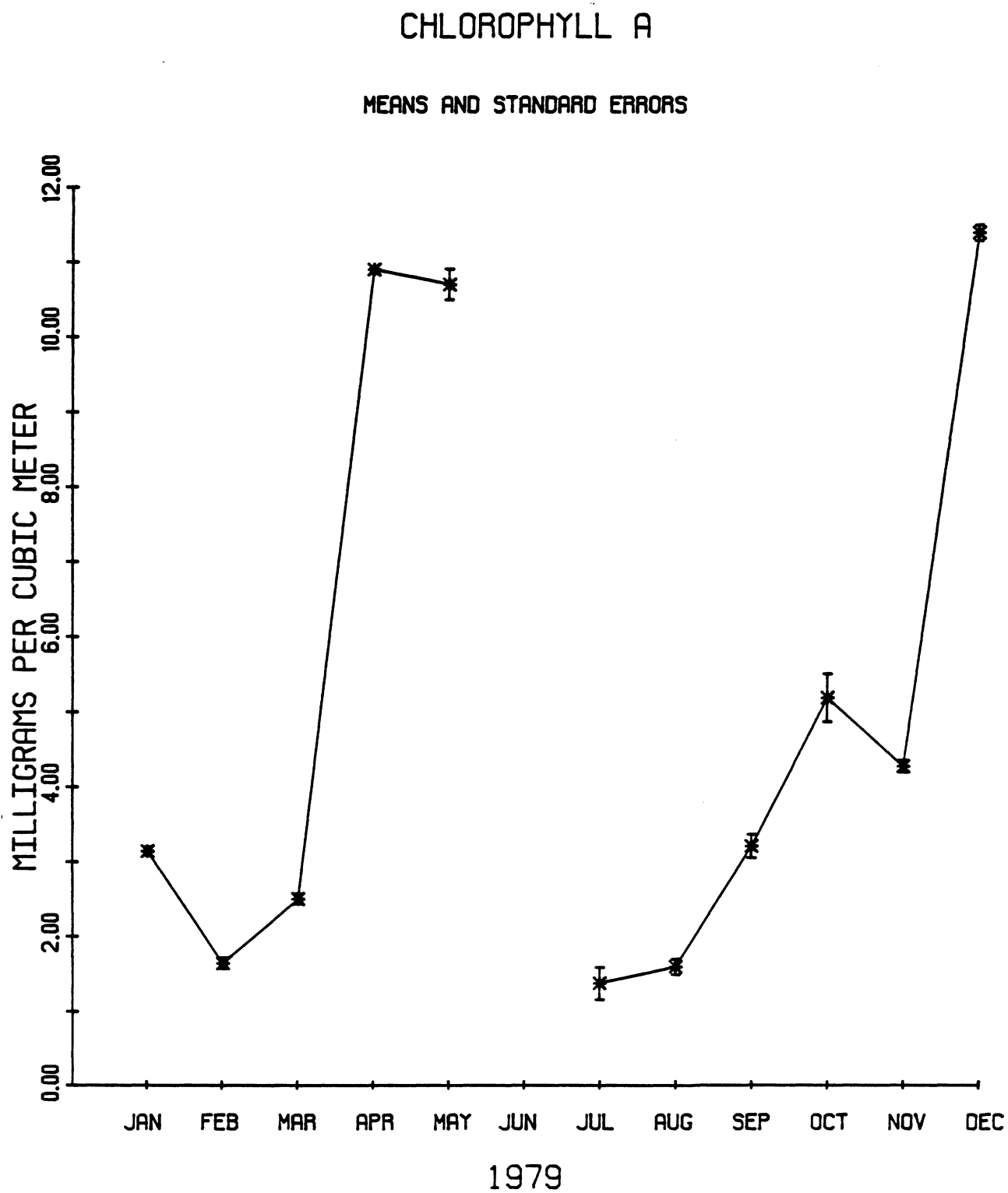


FIG. 15. Variation of chlorophyll a concentrations during 1979.

CHLOROPHYLL B

MEANS AND STANDARD ERRORS

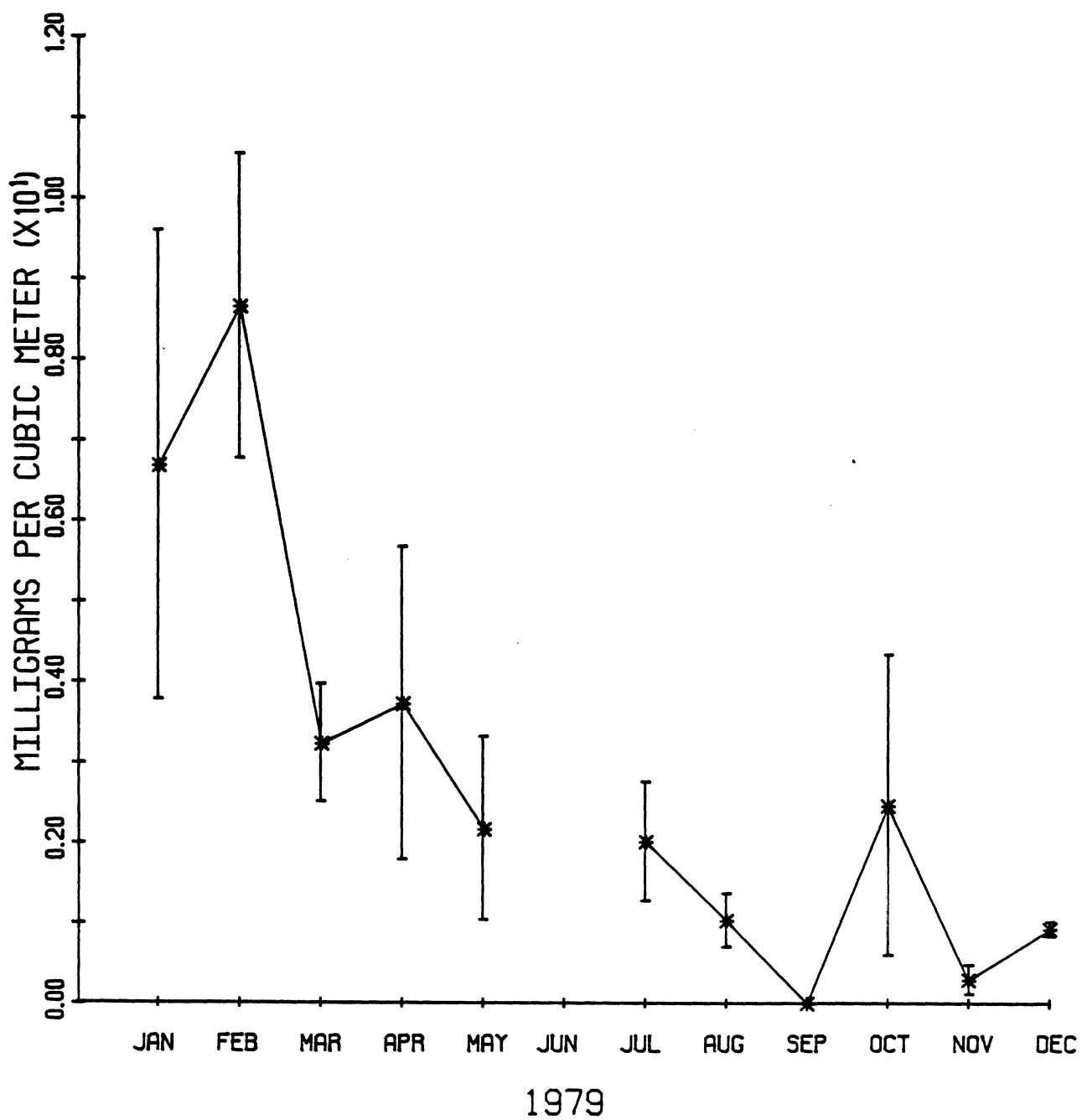


FIG. 16. Variation of chlorophyll *b* concentrations during 1979.

CHLOROPHYLL C

MEANS AND STANDARD ERRORS

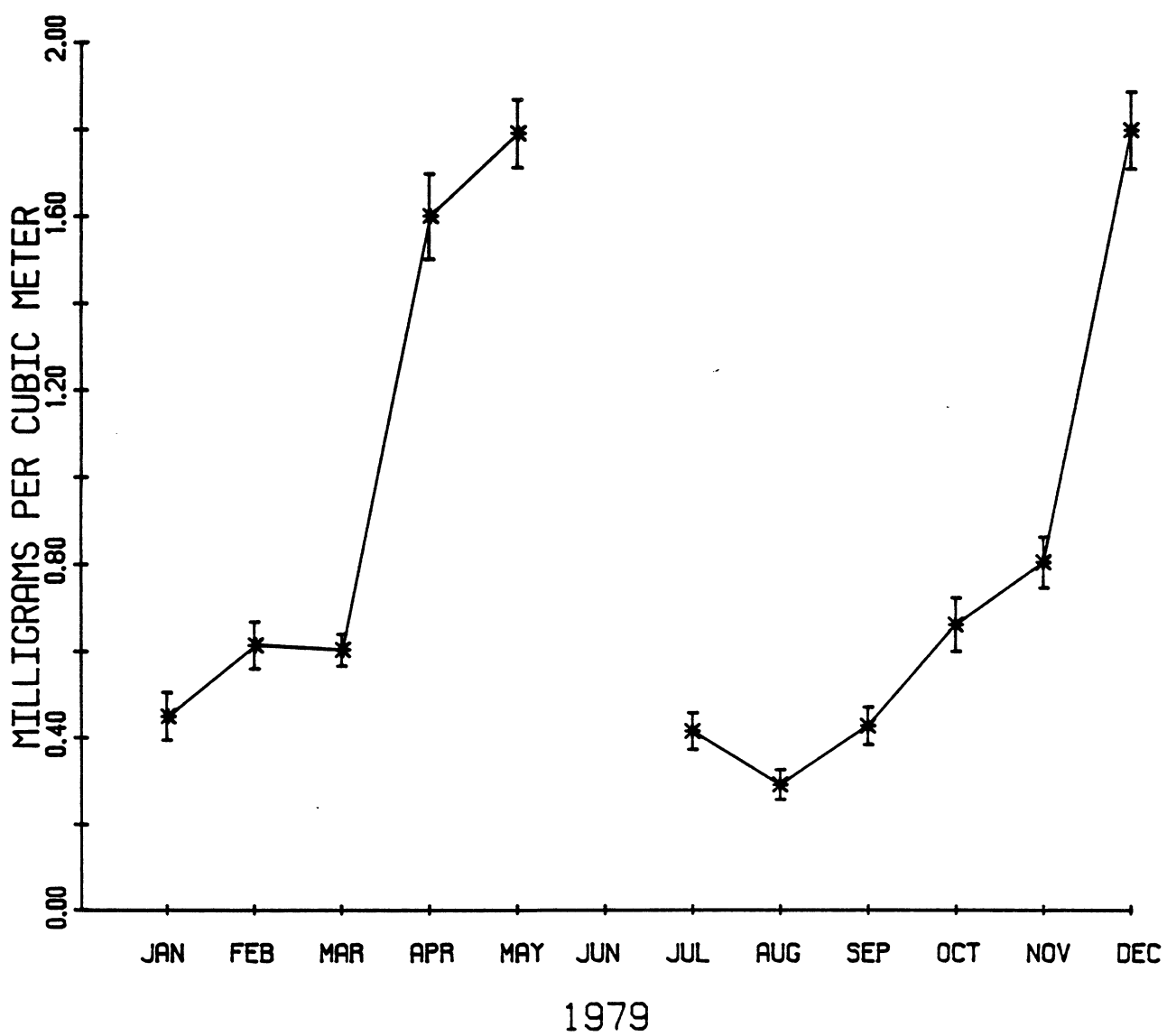


FIG. 17. Variation of chlorophyll *c* concentrations during 1979.

PHAEOPHYTIN A

MEANS AND STANDARD ERRORS

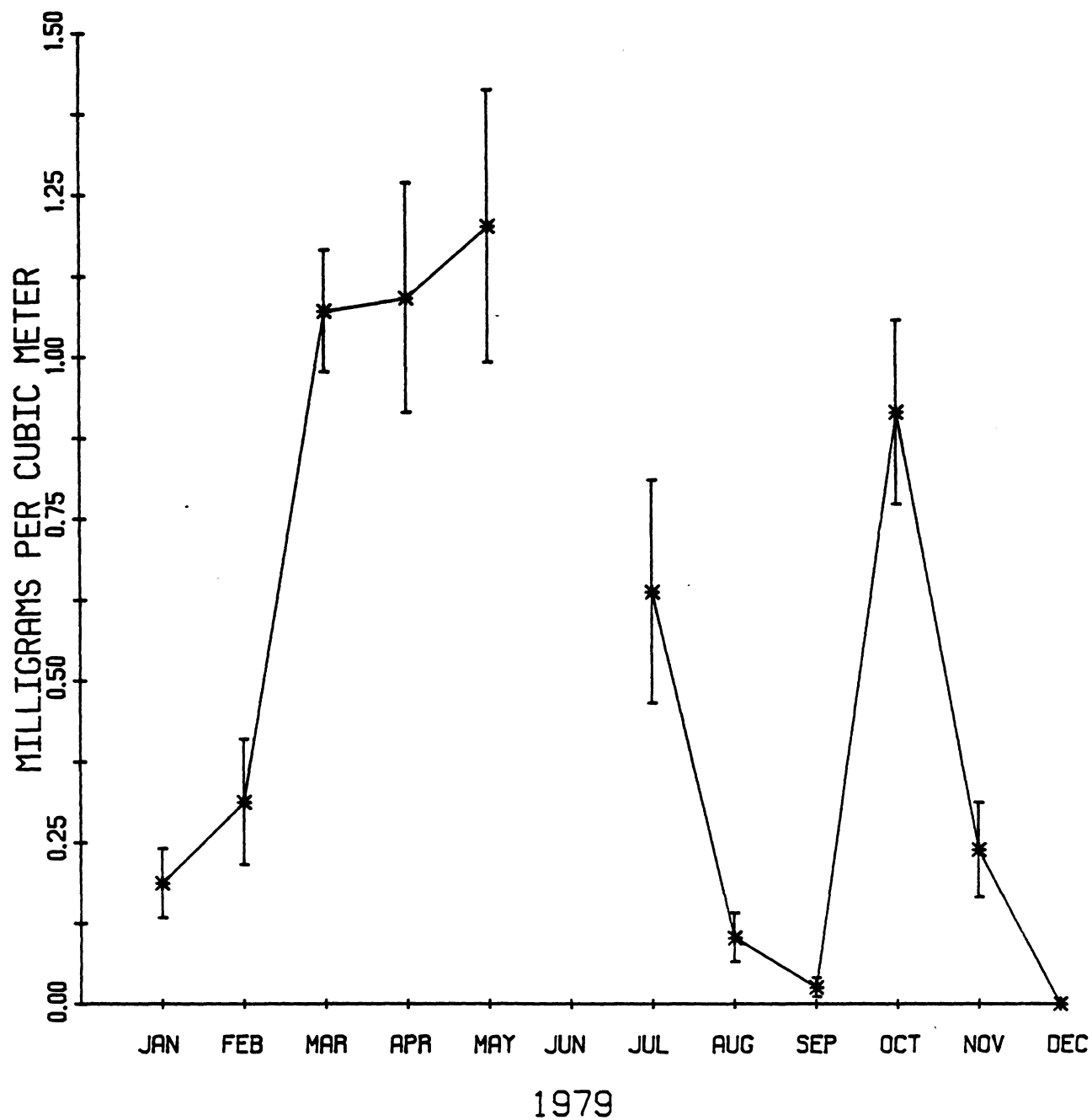


FIG. 18. Variation of phaeophytin a concentrations during 1979.

PHAEOPHYTIN A/CHLOROPHYLL A

MEANS AND STANDARD ERRORS

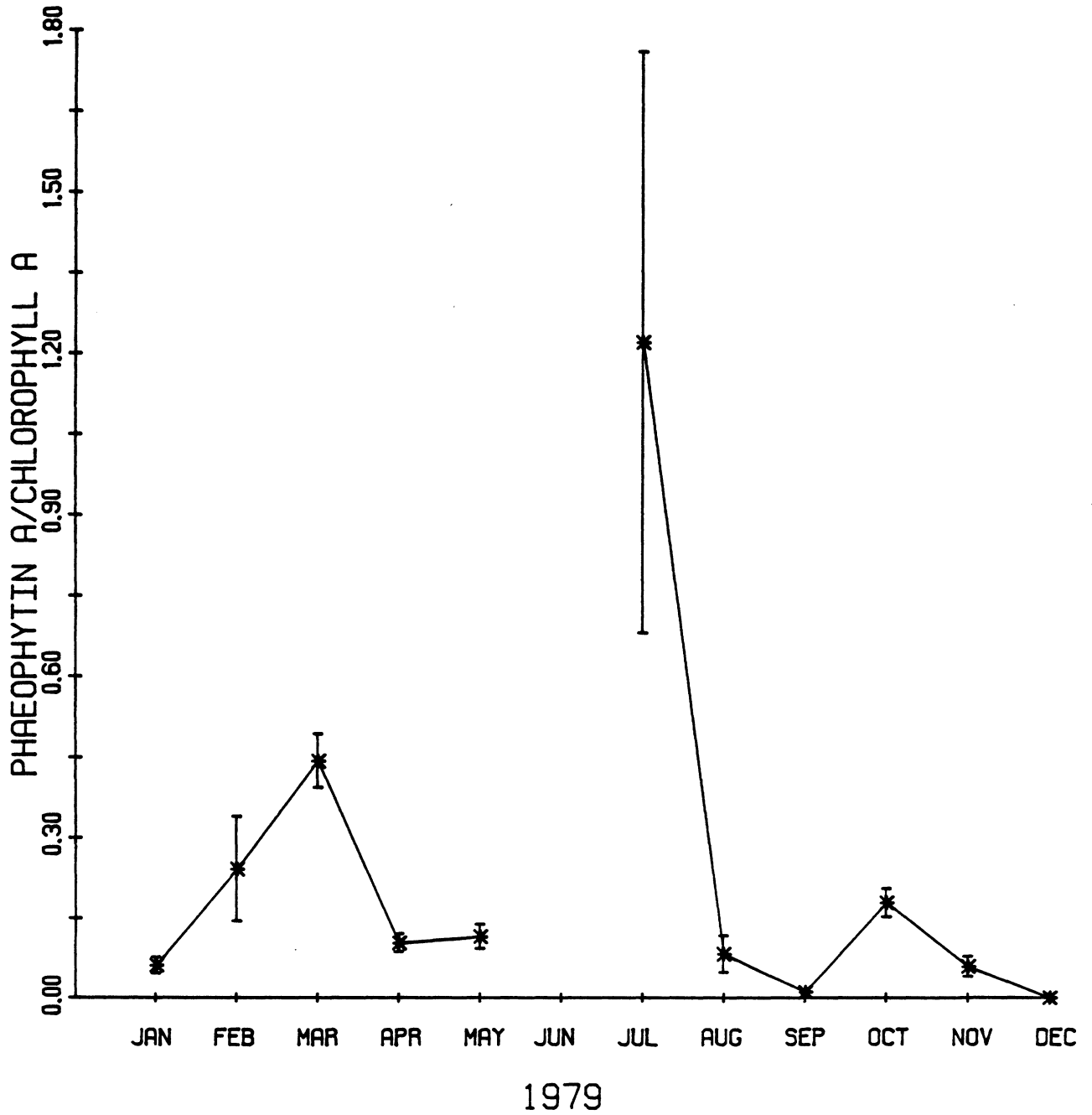


FIG. 19. Variation of the phaeophytin a/chlorophyll a ratio during 1979.

January through April and in August through October. Centric diatoms peaked in April and October and remained low the rest of the year. Pennate diatoms were most abundant in May and December. Desmid numbers were consistently low, with a peak in May. Other algae maintained high numbers during August and October. Total algae numbers were highest in May, October, and December.

Comparison of phytoplankton major group mean concentrations for 1975 through 1979 gave the following general observations: 1) coccoid blue-green algae and desmids were least abundant during 1976; 2) flagellates were least abundant during 1977; and 3) filamentous blue-green algae, coccoid green algae, and centric diatoms were least abundant in 1977. Other algae were most abundant in 1978, and filamentous green algae most abundant in 1976; 4) pennate diatoms and total algae were least abundant in 1979. The reason for this low count in 1979 may be the absence of June samples, when the abundance is usually high. The value for the yearly average may therefore be unduly low.

The number of forms of phytoplankton identified during 1979 varied from 32 in July to 67 in October. Diversity ranged from 3.24 in July to 4.34 in January, and redundancy varied from 0.261 in March to 0.422 in September.

The average number of forms and the redundancy index were highest in 1978, and diversity was highest in 1976 and lowest in 1977. These changes in community structure statistics mimic changes noted in the major forms of phytoplankton. The appearance of the maximum number of forms at the same time as the highest redundancy is an indication of the increasing dominance of relatively few forms in the system despite the increase in overall species number in the system.

Important trends have been observed in entrainment assemblages: 1) a continuous frequent occurrence and large abundance of the blue-green alga

Anacystis incerta; 2) frequent occurrence of Gomphosphaeria lacustris in 1979; 3) a large increase in the occurrence of flagellates in 1979 compared to the previous year; and 4) a continued increase in the occurrence of dominant blue-green algae in 1979, although the magnitude of this increase seems to have leveled off in comparison to previous years.

Viability results based on the comparisons of chlorophyll and phaeophytin a concentrations in the intake and the discharge samples were variable and lacked consistent trends in the years (1975-1979) under consideration. Decreases in viability occurred in 5% of the samples in 1979 compared to 3% in 1975, 5% in 1976, 16% in 1977, and 9% in 1978. Viability increased in 9% of the 1979 samples compared to 9% in 1978, 1% in 1977, 4% in 1976, and 2% in 1975. Except for 1977, this variation is believed to be related to natural changes in the phytoplankton community and to the patchy distribution of phytoplankton.

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